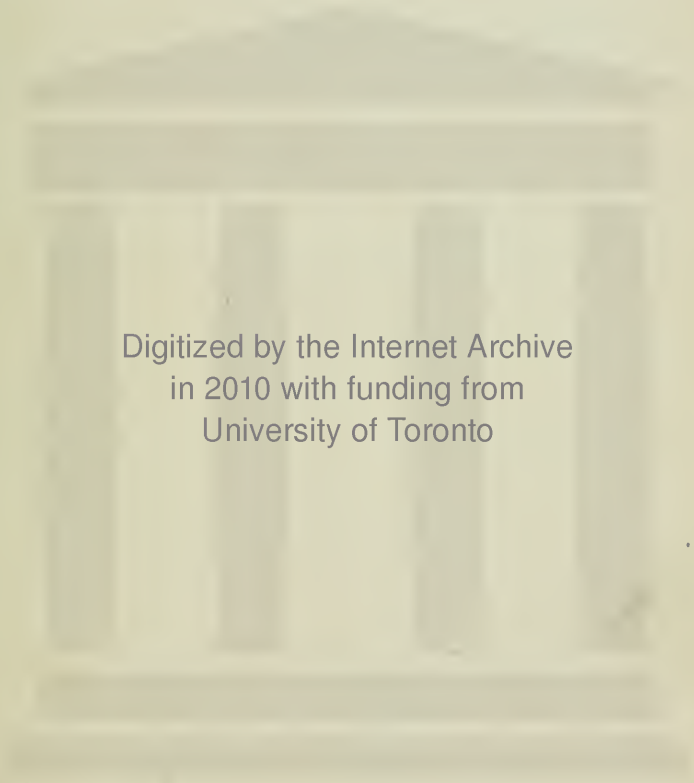






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THE JOURNAL

—OF THE—

FRANKLIN INSTITUTE,

DEVOTED TO

SCIENCE AND THE MECHANIC ARTS.

EDITED BY

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THE Franklin Institute is not responsible for the statements and opinions advanced by contributors to the *Journal*.

THE FRANKLIN INSTITUTE.

Stated Meeting, held Wednesday, October 21, 1903.

The Belmont Filtration Works.

BY JOHN W. HILL.

Chief Engineer Bureau of Filtration, Department of Public Works,
Philadelphia.

The Belmont works for filtering the water supply of West Philadelphia, embracing the 24th, 27th, 34th and 40th Wards, containing at the present time a population estimated at 170,000, are located on Belmont Avenue near the city line. The tract of land taken for these works contains 60.57 acres, lying partly north and partly south of Ford Road, between Belmont and Monument Avenues. Upon the land located north of Ford Road are placed the sedimentation and clear water basins, and on the land south of Ford Road are placed the plain sand filters and preliminary filters. Enough land south of the plain sand filters is unoccupied and reserved for the construction in the future of eight more filters of the same effective sand area as those now built.

The agitation of an improved water supply for West Philadelphia was a strong factor in shaping and promoting

the works which are now being constructed under the ordinances of Councils providing for the improvement, extension and filtration of the water supply.

As early as June, 1898, Councils passed an ordinance

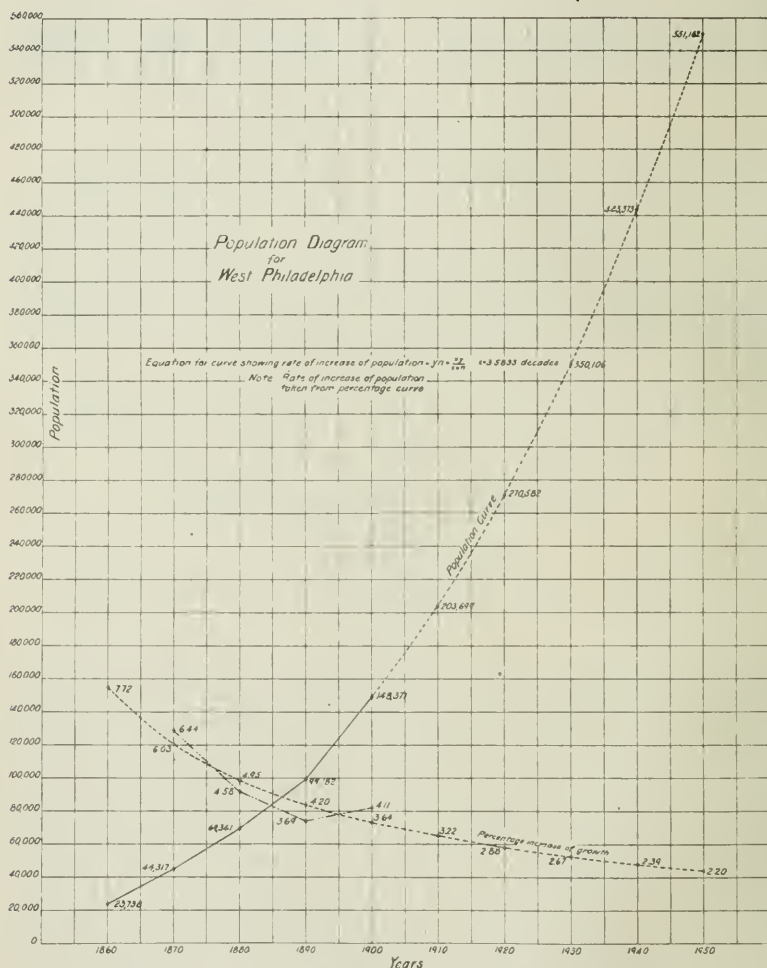


FIG. 1.—Diagram showing population of West Philadelphia.

appropriating \$3,200,000 for the improvement of the water supply, and mainly through the exertions of Hon. Edward W. Patton, member of Councils from the 27th Ward, a provision was incorporated in the ordinance that at least

\$500,000 of this amount should be applied to the improvement of the Belmont Works. The actual outlay for West Philadelphia, including land and the extension of the pipe-distribution system, will be over \$4,000,000.

POPULATION.

West Philadelphia, as shown by the census enumerations from 1860 to 1900, inclusive, has been growing at a greater rate than that portion of the city lying between the Delaware and Schuylkill Rivers, and as a preliminary step in determining the capacity of the works of filtration required for the present and future supply of this section of the city, a careful study of the past and prospective growth of population was made.

By inspection of the diagram (*Fig. 1*) it will be seen that from a population of 23,738 in 1860, it has grown to 148,371 in 1900, and by plotting the mean annual rate of growth for each census decade, and drawing a smooth curve through the points on the diagram, the smoothed rates of growth from 1860 to 1950, stated as the mean annual increase, are as follows :

	Per Cent.
1860	7.72
1870	6.03
1880	4.95
1890	4.20
1900	3.64
1910	3.22
1920	2.88
1930	2.63
1940	2.39
1950	2.20

Corresponding to the following future populations :

1910	203,699
1920	270,582
1930	350,106
1940	443,373
1950	551,162

Upon a basis of 150 gallons of water per capita per day the consumption of water for each ten years of the next five decades should run about as follows :



FIG. 2.—Belmont filters and reservoirs.

	Gallons Per Day.
1910	30,554,800
1920	40,637,300
1930	52,515,900
1940	66,506,000
1950	82,674,300

The present consumption of West Philadelphia is, as an average, 185 gallons per capita per day, and if steps are not taken to reduce the unnecessary and avoidable waste of water, the consumption by 1950 will reach over 100,000,000 gallons per day, or about the ultimate capacity of the Belmont works.

In the report of the Expert Commission appointed by Mayor Samuel H. Ashbridge, May, 1899, it is stated that the least flow of the Schuylkill River has been shown to be about 150,000,000 gallons in twenty-four hours, and that it was thought prudent to not exceed this quantity as the maximum daily consumption of water from this source.

Apportioning this consumption of Schuylkill River water between West Philadelphia and Roxborough, it has been assumed that if the present rate of consumption is maintained, these two districts will require respectively 100,000,000 gallons and 50,000,000 gallons per day within the next fifty years—the entire allowable quantity which, according to the experts' report, should be drawn daily from the Schuylkill River.

PRINCIPAL DETAILS.

The Belmont Works consist of two subsiding basins, each containing at flow line about 36,000,000 gallons of water, which, at the present rate of consumption, represents 2'40 days' sedimentation of the water before it is drawn from the basins; eighteen plain sand filters, in part modeled after the filters at Berlin, Warsaw and St. Petersburg, and in part after the newer filters at Hamburg; a system of preliminary filters adapted at a rate of 80,000,000 gallons per acre per day, to deal with 40,000,000 gallons of water daily, and a clear water basin, 15 feet in depth, with a capacity of 16,500,000 gallons; eight hopper sand washers, patterned after the washers in use at the Hamburg filters; an admin-

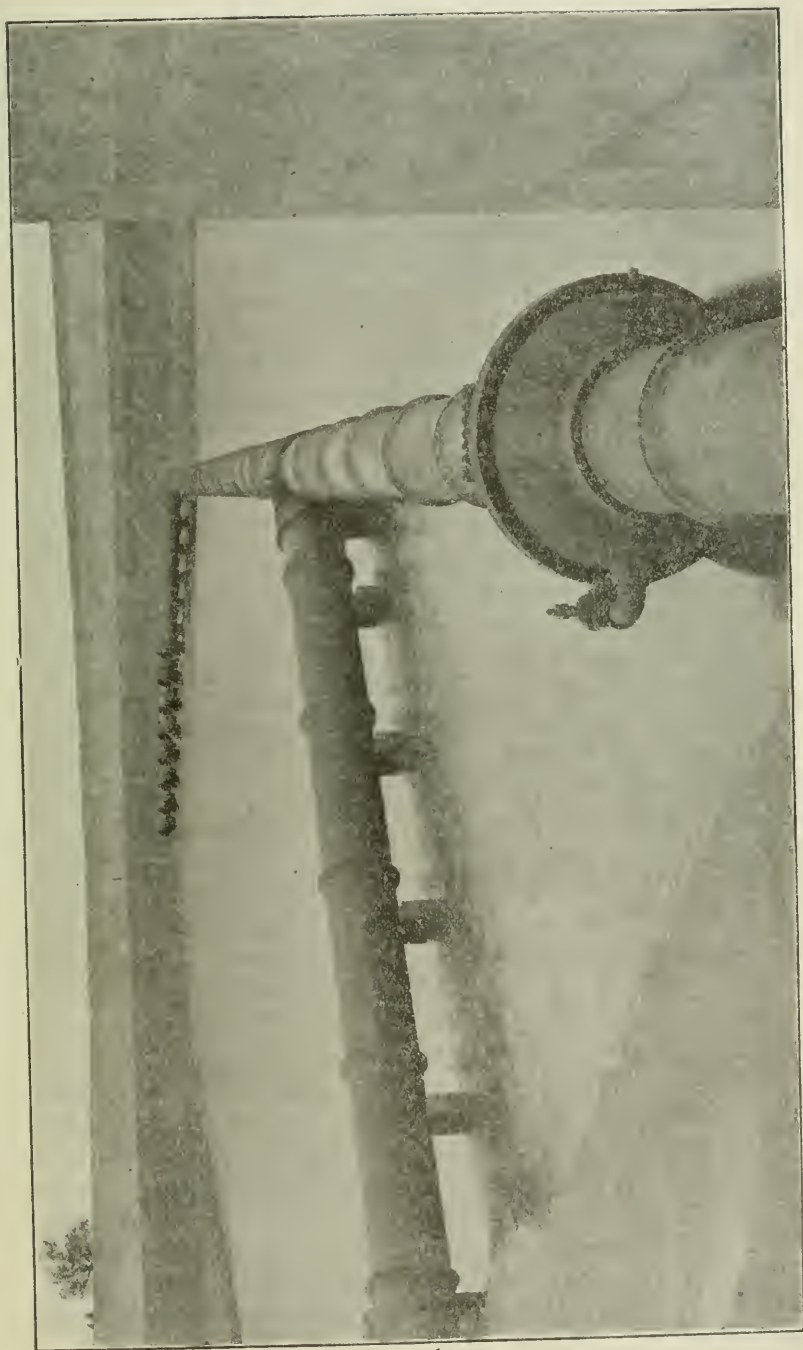


FIG. 4.—Sedimentation reservoir. East division.

istration building and pumping station; centrifugal pumping machinery to supply wash water to the preliminary filters; direct acting plunger pumps to supply water under pressure to the sand washers; steam boilers for power and heating the buildings, and an electric lighting equipment.

Considering the chief features of the works, *Fig. 2* shows the location of the sedimentation reservoir, preliminary filters, plain sand filters, the clear water basin and the administration building.

Belmont Avenue, as will be noticed from the meridian symbol, has a nearly north and south direction. With this explanation it will be seen that the sedimentation reservoir occupies the land bounded on the west by Belmont Avenue, on the north by City Avenue and Overbrook Avenue, and on the south by Ford Road. The preliminary filters are located at the intersection of Belmont Avenue and Ford Road. The plain sand filters are located along the east side of Belmont Avenue, the south side of Ford Road, and the west side of Monument Avenue, and the clear water basin at the intersection of Ford Road and Monument Avenue. The unoccupied land, which is shown with contours south of the plain sand filters, is reserved for an addition of eight filters of the same general dimensions as those shown. The small rectangles, of which there are eight, shown in the court between the filters, indicate the location of the sand washers. Between the preliminary filters and the group of six filters on Belmont Avenue is placed the administration building and boiler and pump rooms.

SEDIMENTATION RESERVOIR.

(Contract No. 16.)

The sedimentation reservoir consists of two divisions, or basins, each 25 feet deep, measured at the flow line, elevation, 279'00 C. D., and 29 feet deep from the top of embankment, elevation 283'00 C. D. The area of the east division at the flow line is 5'43 acres, and at the floor line 3'47 acres. The area of the west division at the flow line is 5'33 acres, and at the floor line 3.037 acres. The inside and outside slopes are, at all points around the basins, two horizontal to one vertical.

Top width of embankment, 18 feet; width at toe of inner slope, 134 feet. The east division was constructed about equally of cut and embankment, while the west division, excepting the embankment along Ford Road, was nearly all in excavation, some of which was quartzlike trap rock. The materials of excavation consisted of clay, micaceous rock, sand, gravel and hard rock, the latter requiring drilling and blasting for its removal.

In making embankments, the best materials of excavation were placed next the inner slope, and all materials were rolled in thin layers. When the excavation in rock discovered fissures, these were filled with grout, and the irregular surfaces of the rock in the floors, and slopes leveled up to sub-grade partly with concrete and partly with clay puddle.

In preparing the ground for rolled embankment for the sedimentation reservoir the top soil was first thoroughly stripped off and the inclined ground stepped in horizontal terraces.

The reservoir embankments and the fill under the filters on Monument Avenue were rolled with four 25-horse-power traction engines weighing 10 tons each, or 3,300 pounds per foot width of roller wheels, two 18-horse-power traction engines weighing approximately 8 tons each, or 3,000 pounds per foot width of roller wheels, and one 10-ton traction roller, manufactured by the Julius Scholl Company of New York. All rollers were grooved.

In the original plan of the reservoir, as shown in *Fig. 3*, the inner slopes were constructed with a berm at an elevation of 12.7 feet above the finished floors of the basins, and the upper slope set back a distance of five feet to receive a granite block paving to be set dry, and backed with broken stone. This was intended as a protection to the puddle lining from frost, but further consideration of this feature of the construction raised doubt of its utility, and it was omitted in finishing the basins. Each division of the reservoir is lined on the floor and slopes with 18 inches of clay puddle, on which is placed a 6-inch course of concrete. On the concrete to within a vertical depth of 10 feet from the water line is placed a $\frac{3}{4}$ -inch mixture of asphalt, asphaltic

mastic and grit. *Fig. 8* shows the height on the slopes of the asphalt lining.

In the division wall between the two basins, which is constructed partly in excavation and partly of embankment, are placed two equalizing or pass pipes, which, when the valves are opened, maintain a uniform elevation of water surface in both divisions of the reservoir. Each of these pipes is supplied with a floating inlet pipe, which receives the water at the surface of the reservoir and conducts it to the pass pipe and thence to the opposite side of the division wall, where it is discharged at the bottom of the basin. The equalizing pipes, and the influent and effluent pipes, are placed in trenches provided with concrete cut-off walls, the spaces between which, under, around and over the pipes, are packed with well-rammed puddle.

Fig. 4 shows the 48-inch diameter influent pipe in the east division of the reservoir, into which is connected, at the angle near the center of the basin, the equalizing pipe from the west division of the reservoir. The influent pipe crosses the basin diagonally from the southwest to the northeast corner, and terminates in a set of fourteen 48-inch tees and one 48-inch elbow, with the branches turned slightly upward from the horizontal, as shown. The line of pipe and special castings are supported on low brick piers set on the asphalt lining of the floor. By means of the arrangement of shown pipes, the water from the Schuylkill River at the Belmont Pumping Station is passed diagonally from end to end and from the bottom to the surface of the water in each division of the sedimentation reservoir. It is thus hoped that currents having a tendency to carry the heavier suspended matter out of the reservoir, will be avoided.

In the line of each influent pipe is placed a 48-inch check valve, made by the Ludlow Valve Company of Troy, New York. Each of these check-valves weighs about 32,000 pounds.

The subsided water is conducted from either division of the reservoir to the screen-chamber, and thence to the preliminary filters through floating pipes, one of which is shown lying on the floor to the left of the effluent chamber in

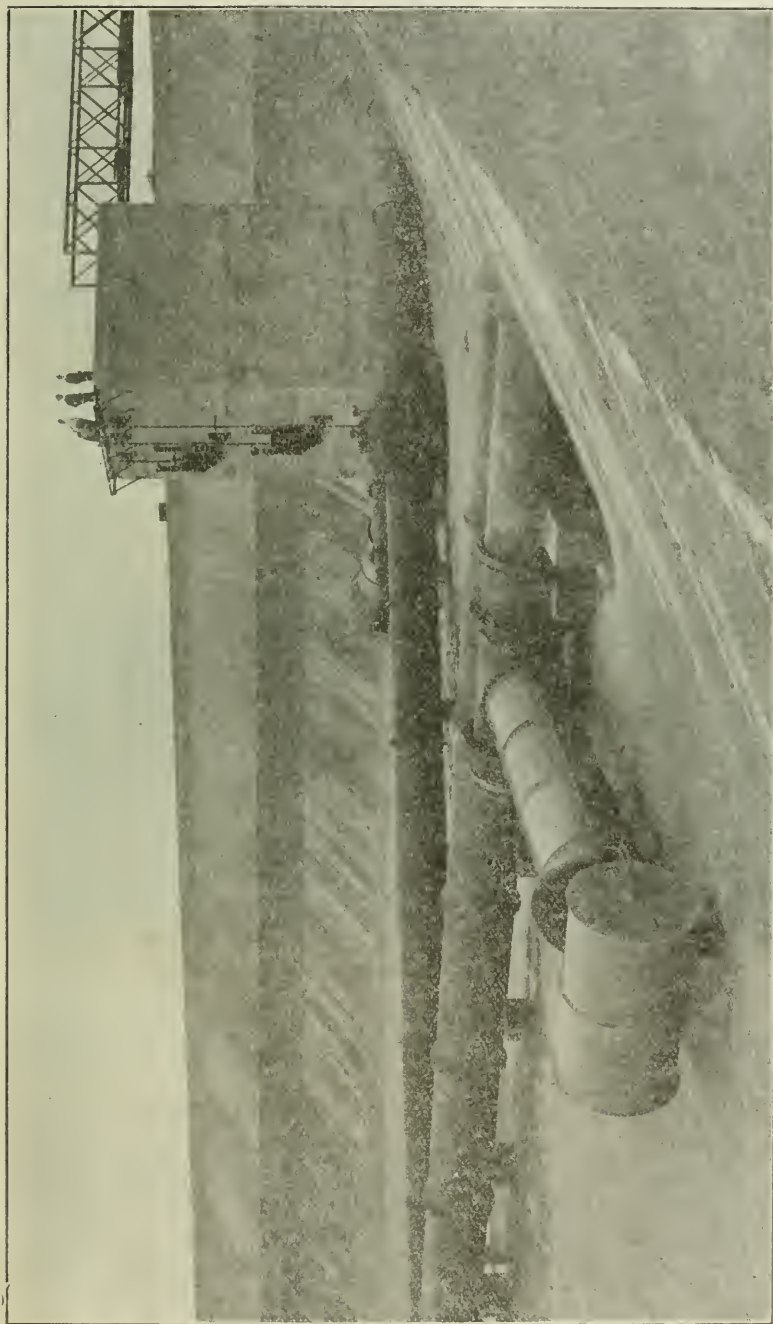


FIG. 5.—Screen chamber and floating pipes.

Fig. 5. This pipe, 48 inches diameter, is made of galvanized sheet-iron, attached at the lower end to a 48-inch swiveling tee, mounted in bronze bearings, and at the upper end by flexible connections to a float which consists of a galvanized sheet-iron, water-tight cylindrical barrel, which allows the mouth of the pipe to be submerged a few feet below the surface of the water.

Should the floating pipe for any reason fail to act, water can be drawn through either of the three sluice-gates shown



FIG. 6.—Sedimentation reservoir. Gate-house.

on the inside face of the effluent chamber, each being provided with a compound geared gate-stand on the top of the effluent chamber.

In the gate-house, *Fig. 6*, are placed eleven 48-inch diameter Ludlow stop-valves, which control the flow of water into and out of the reservoir, each of which is provided with a compound geared gate-stand and extension stem to operate from the floor of the house. The gate-house, when the works are completed, will have a frontage on the north property line of Ford Road sufficiently elevated above the

grade of the street to make a neat and pleasing feature of the works.

The plan of the influent and effluent pipes where they pass through the gate-house, is such that the raw water may be delivered entirely into one division of the reservoir and drawn from the other; or may be delivered into and drawn from each division at the same time; or one basin can be cut out of service entirely; or one of the two supply pipes entering the gate-house from the left, will supply into both or either division of the reservoir, and likewise the subsided water can be directed into either of the two lines of 48-inch effluent pipes shown at the bottom of *Fig. 7*.

The two lines of rising pipe which bring the water from the Belmont Pumping Station to the gate-house are each 36 inches in diameter.

In the upper part of the gate-house is constructed a room for the reservoir watchman, access to which is had by means of a spiral iron staircase.

All the joints in the gate-house, excepting the last joint in each line of pipe, are made with flanges and bolts and gaskets.

PRELIMINARY FILTERS.

(Contract No. 38.)

Fig. 8 shows in place the first installation of preliminary filters, placed in the center of the ground lying between Ford Road on the north and plain sand filter No. 6 on the south.

South of the first installation of filters, ground is reserved for an addition of 25,000,000 gallons daily capacity, and north of the first set of filters, space is left for a further addition of 30,000,000 gallons daily capacity, or an ultimate aggregate daily capacity of 95,000,000 gallons.

In the arrangement of the 48-inch main pipes to conduct the water to and from the preliminary filters, provision has been made for the necessary influent and effluent connections to the future installations, and to admit of these connections being made without interrupting the service of the first set of preliminary filters.

Connection of the two 36-inch rising mains in Belmont

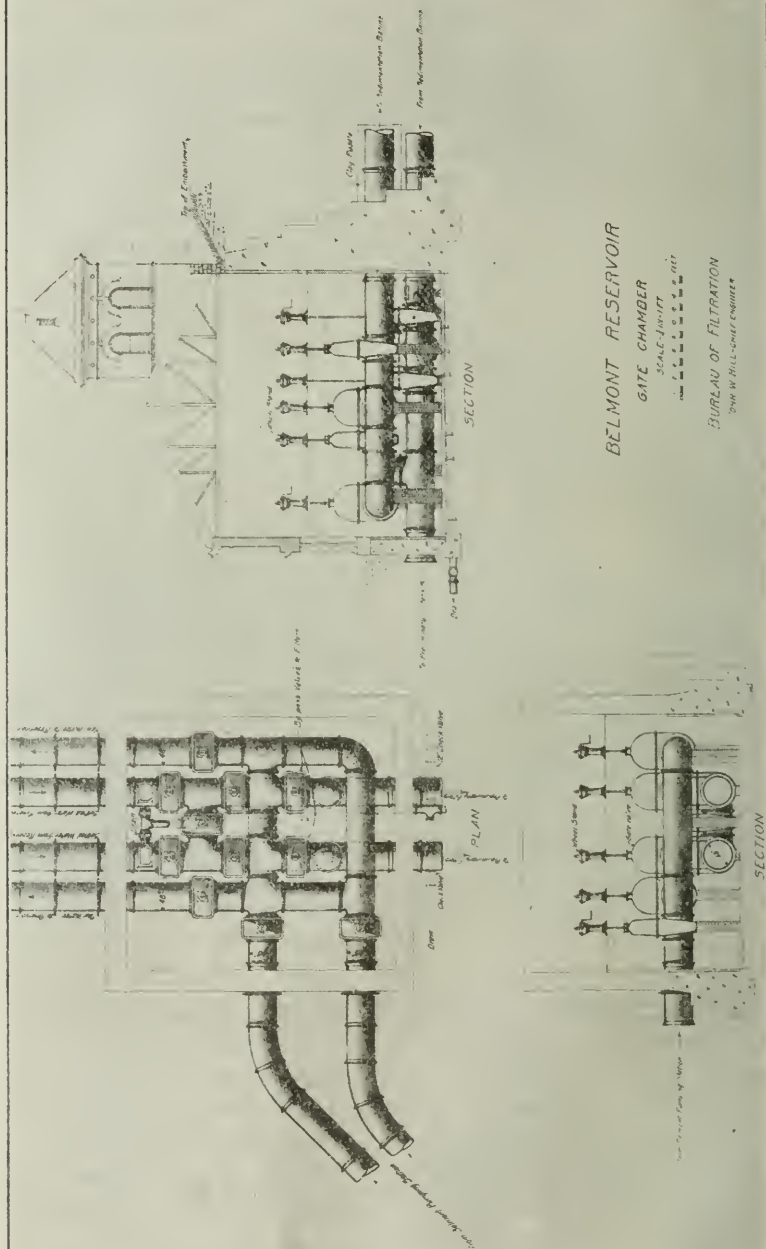


FIG. 7.—Sedimentation reservoir. Section through gate-house.

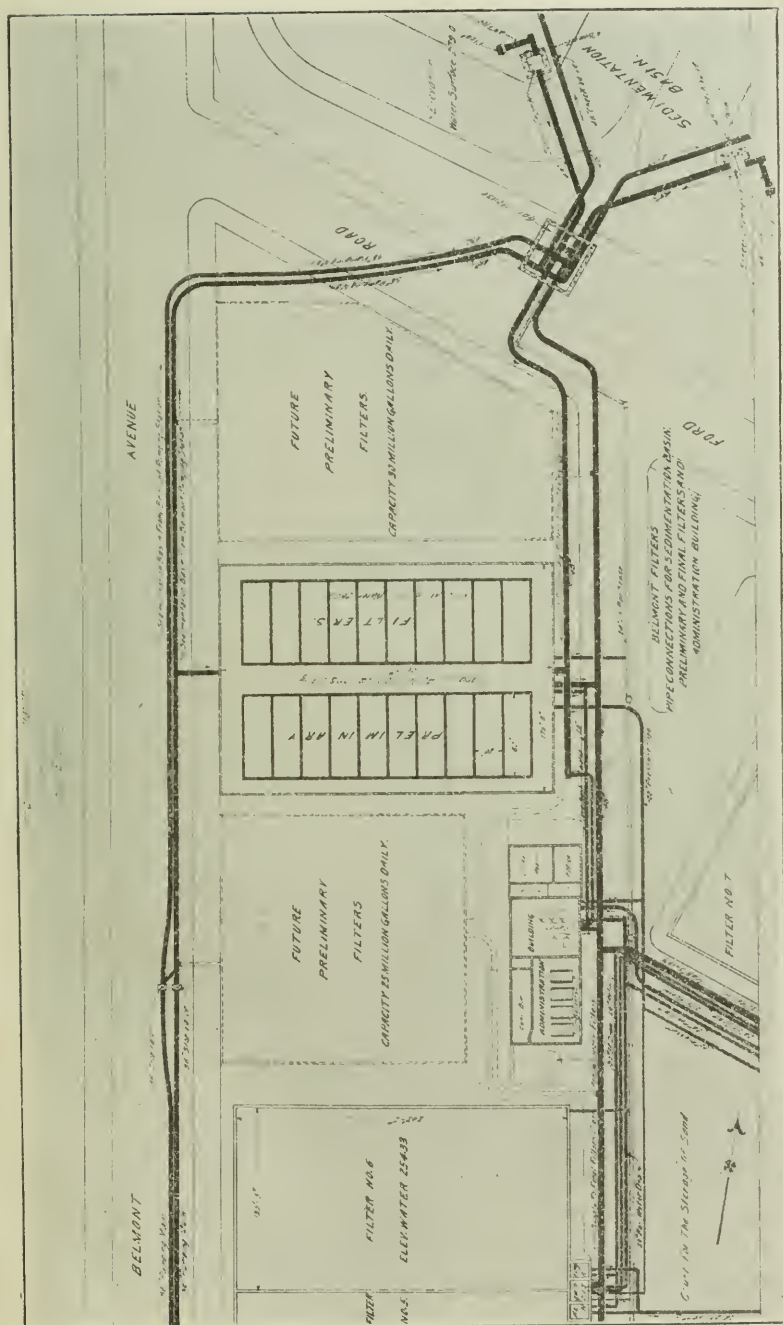


FIG. 8.—Influent and effluent pipes. Preliminary filters.

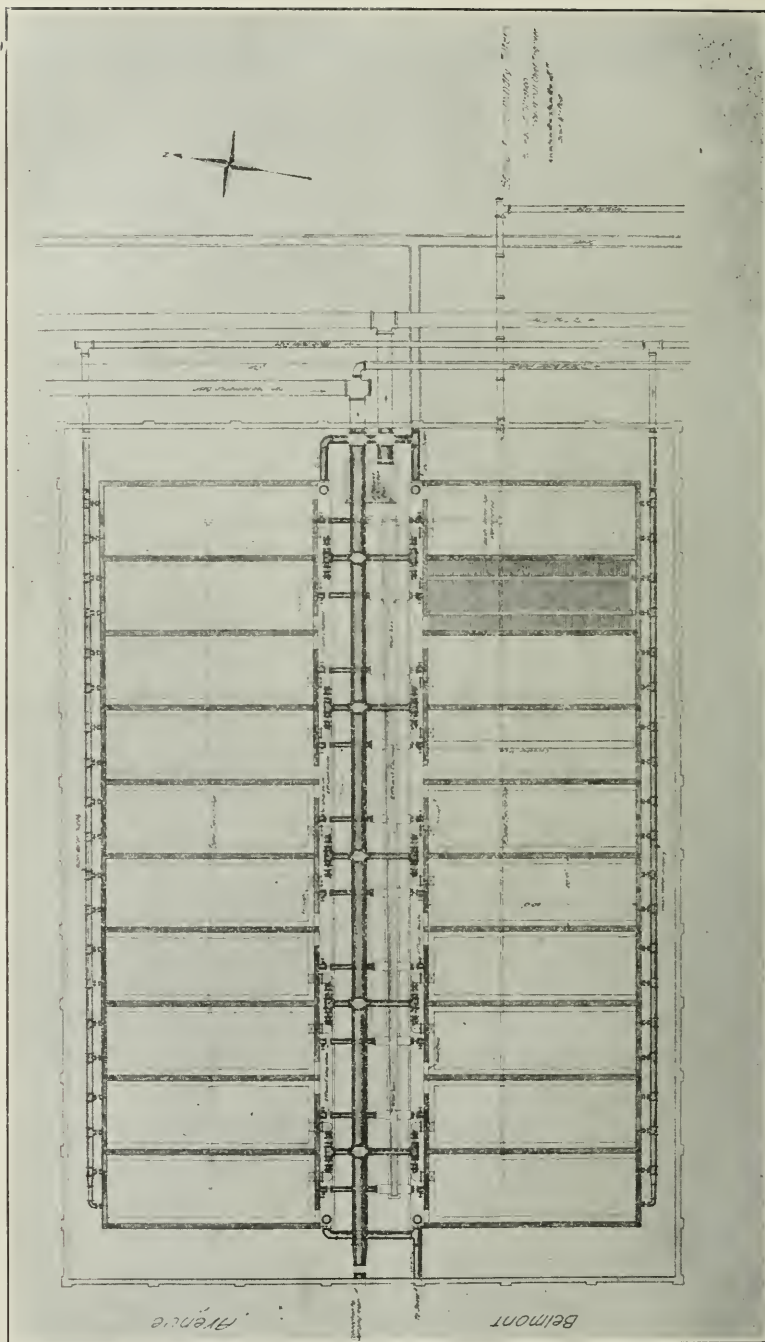


FIG. 9.—Plan of preliminary filters.

Avenue with the main influent pipe of the preliminary filters, is also made to admit of the pumping of water direct to the filters at any time when it might be necessary to take the sedimentation reservoir temporarily out of service. Likewise, if for any reason it might become necessary to take the preliminary filters temporarily out of service provision has been made to draw water direct from the subsiding basins to the plain sand filters.

As a measure of economy in the operation of the works, and to attain the highest possible efficiency in filtration of the water, the system of operation should consist of limited subsidence in the sedimentation reservoir, preliminary filtration, and final filtration.

The preliminary filters, as planned by the Bureau of Filtration, *Figs. 9 and 10*, consist of twenty concrete tanks each 60 feet long, 20 feet wide, 8 feet 6 inches deep. In the bottom of each tank is first placed 12 inches of gravel, ranging in size from $2\frac{1}{2}$ inches to $\frac{1}{4}$ inch in diameters, and above this a layer of 30 inches of coarse sand, consisting of grains which will pass a No. 6 sieve and be retained on a No. 30 sieve. Such sand will be coarser and of more nearly uniform grain than that used in the plain sand filters.

The water from the subsiding basins is introduced at the top of the filter and percolates at a high rate downwards through the bed of coarse sand to the layer of underdrain gravel at the bottom, through which it flows in many streams to a main collector placed in the center of the filter, and thence out of the filter over a measuring and regulating weir to an open duct built of concrete, which in turn conducts the rough filtered water to the 48-inch cast-iron supply pipe of the plain sand filters.

At the level of the gravel under-drains is placed a system of wash pipes consisting of two lines of 12-inch main pipe, from each of which 2-inch branch pipes placed on 8-inch centers extend right and left under the sand bed to the opposite main pipe and side walls of the tank. The main pipes and branch pipes are perforated on the upper side. Water under a head of fifty feet will be used to wash the sand bed by reverse current, or rather by forcing the wash water from

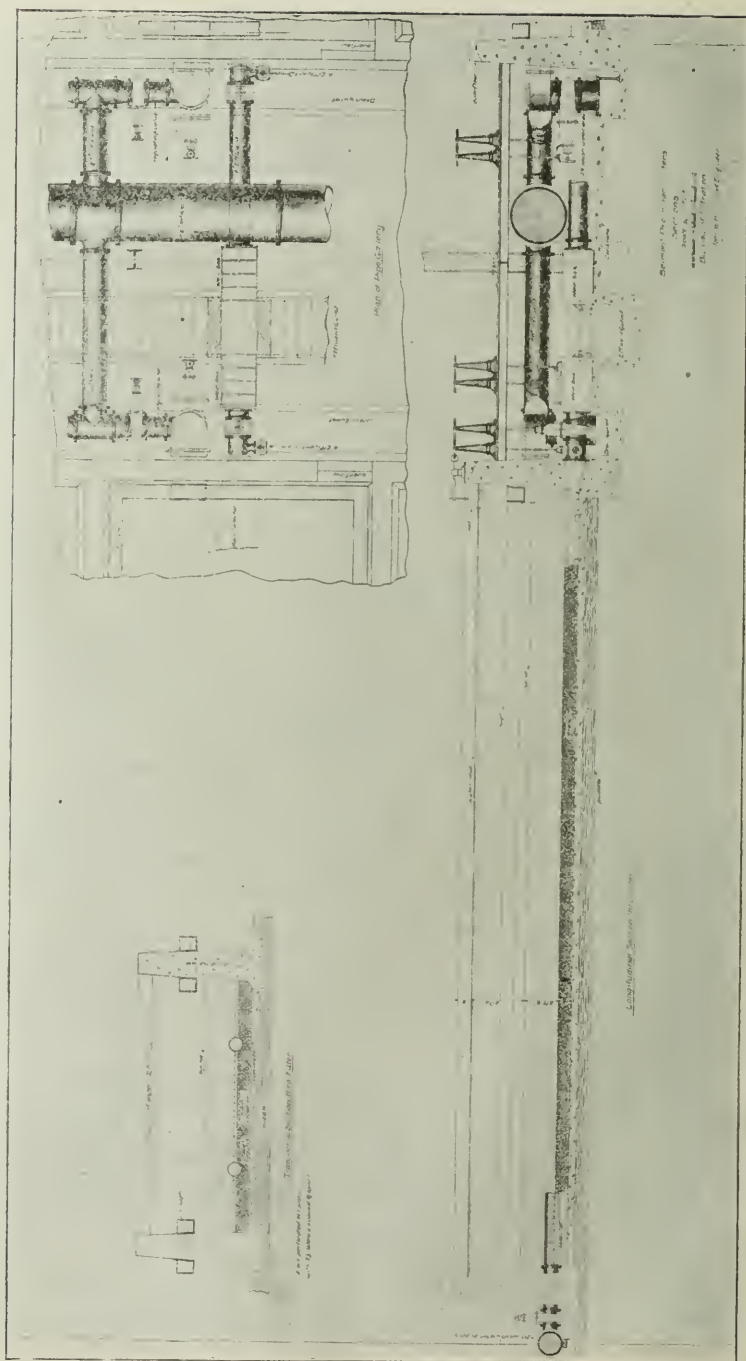


FIG. 10.—Section through preliminary filters.

below upwards in the same manner as in several types of the mechanical filter, excepting that the wash-water pipes are not effluent pipes, as they are in the mechanical filter when operating under normal conditions. Overflow troughs are placed around the filter tank at an elevation about 12 inches above the level of the sand bed, adjustable as to height. These troughs receive the wash water and conduct it out of the filter to a waste gullet of concrete placed in front of the filters.

From an experience of eighteen months with an experimental mechanical filter, 10 feet diameter, at the Spring Garden Testing Station, in use for part of the time without agitation of the sand bed with rakes or by other means, it is thought that mechanical agitation of the sand bed of the preliminary filters while washing is not essential, and that a washing daily, or as often as the loss of head in the operation of the filter may show to be necessary, with the occasional removal from the tank and washing of the sand in hopper washers, will restore the sand bed to its normal condition at less cost of operation and with less chance of interrupting the work than by the use of mechanical agitating devices, or with agitation by means of compressed air.

The principles of construction and operation of the preliminary filters are essentially the same as that of the plain sand filters, excepting the filtering materials are coarser and the sand bed will not be scraped periodically, but washed by a current of water from below upwards daily, or as often as may be required, and the rate of percolation will be maintained at about fourteen times the rate of percolation adopted for the plain sand filters.

The purpose of the preliminary filters at Belmont, and at the other works forming part of the improvement of the water supply, is three-fold: Primarily to enable the plain sand filters to operate at a higher rate than has heretofore been employed and correspondingly reduce the acreage of filter surface required to treat the whole water supply. Next, to prolong the life or rather to increase the yield of the plain sand filter between scrapings from 60,000,000 or 70,000,000 gallons per acre to from 90,000,000 to 150,000,000 gallons per acre,

and finally to maintain a more regular effluent than is possible with the plain sand filter when supplied with water which has been under either quiescent or continuous subsidence for a day, or for a few days.

The preliminary filters are intended to perform in a short time what could be accomplished only in a very long time by sedimentation reservoirs.

The capacity of the Belmont preliminary filters is based upon a rate of percolation equivalent to 80,000,000 gallons per acre per day, and at this rate nineteen of the twenty tanks will each furnish 2,200,000 gallons of rough filtered water, or pre-filtered water, per day.

In the operation of the preliminary filters, one filter containing only the gravel and underdrains will always be out of service, so that, when either of the filters becomes clogged with "mud balls" so as to demand a washing of the filter-sand, this sand will be thrown out of the filters by means of the ejector (presently to be described in connection with the removal of sand from the plain sand-filters) into a three-hopper ejector-washer and delivered from the washer into the empty filter. Thus it will be seen that the sand in transportation and washing will be worked from filter to filter, and, excepting at such times when one filter will be out of service for washing, and one filter receiving the washed material, there will always be nineteen filters in service. It is estimated that it will require about eight hours to remove and wash the sand and replace it in the empty filter. When the operation of washing by the hopper-washers has been performed, the sand will then be in the same condition it was when the filter was first started in service.

Experience at the Spring Garden Testing Station has shown that even with the addition of the revolving rake agitator the reverse current of water is not capable of thoroughly washing and preventing the formation of some "mud balls" in the body of the sand, excepting with a wasteful expenditure of water, and it is anticipated that the cost of prefiltering the water, including the washing and transportation of the sand by means of the sand-ejector and

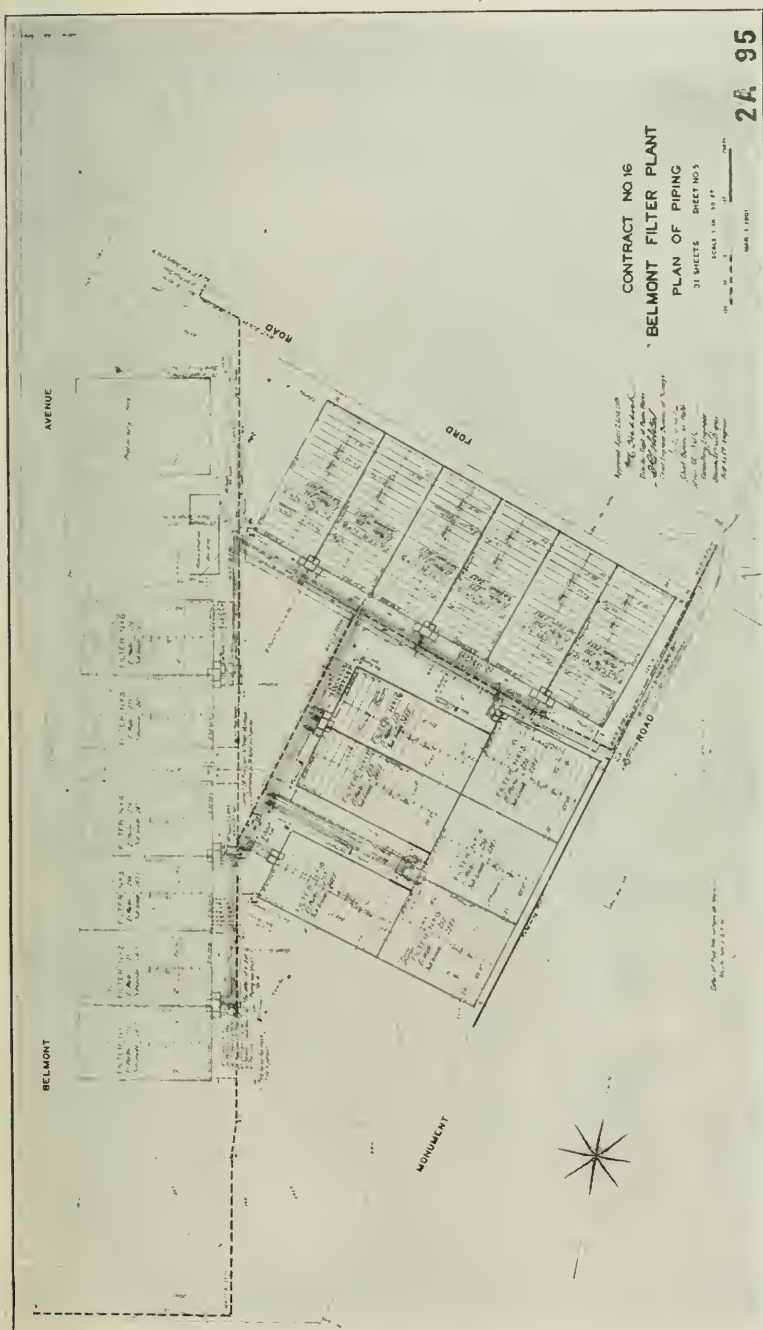


FIG. 11.—Plan of plain sand filters.

ejector-washer, will be less than the cost of wash-water power and repairs to operate a filter with a mechanical agitator.

PLAIN SAND FILTERS.

(Contract No. 16.)

Fig. 11 shows the eighteen plain sand filters now rapidly nearing completion under Contract No. 16. Six of these filters lie along Belmont Avenue, six along Ford Road, and six along Monument Avenue. The plan of the land taken by the city for the works rendered it impossible to maintain a standard of length and width of filter, as at Upper and Lower Roxborough, and generally at Torresdale, and, while the effective sand area is about the same for all filters, in planning the works it was found convenient to vary the relation of length and width to suit the ground.

The horizontal dimensions of the eighteen filters are given in the following table:

DIMENSIONS OF FILTERS.

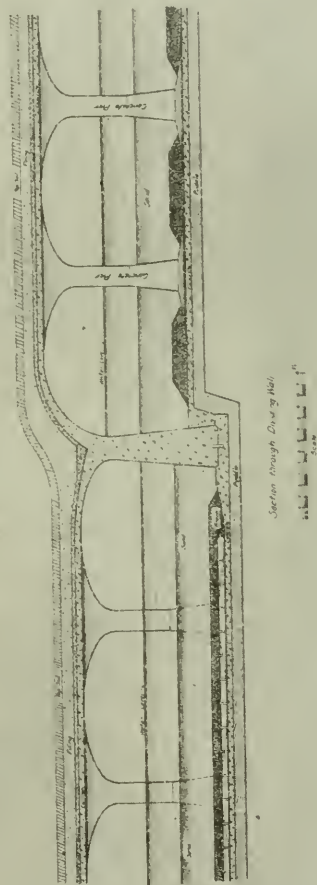
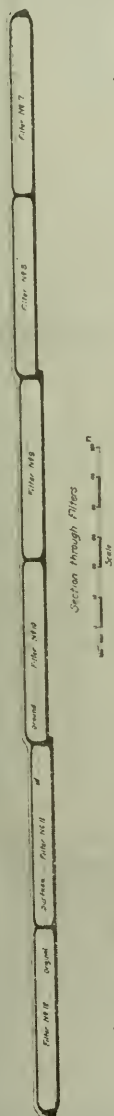
7 Filters	242 feet 2 inches long,	135 feet 5 inches wide
8 "	272 " 8 " "	120 " 2 " "
3 "	196 " 5 " "	165 " 11 " "

The contours of the land also was such as to make it inconvenient to locate all of the filters at common elevation, as at Upper Roxborough and Torresdale, and the terraced arrangement, through the six filters on Belmont Avenue, shown by *Fig. 12*, was resorted to.

This involved a slight loss of head between the level of water in the sedimentation reservoir and in the clear-water basin, which was diminished as much as possible by rolling into fills on the ground at lower elevation, the excavation taken from the filters built on the ground at higher elevation.

The elevation of the normal flow-lines, or of water above the sand beds, is shown in the following tables:

5 Filters, elevation	248'33 C.D.
2 " "	250'33 "
5 " "	251'33 "
2 " "	252'33 "
4 " "	254'33 "



Bureau of Filters

Terraced Arrangement of Filters

Bureau of Filtration

John W. Hill, Chief Engineer

FIG. 12.—Section showing terrace arrangement of filters.

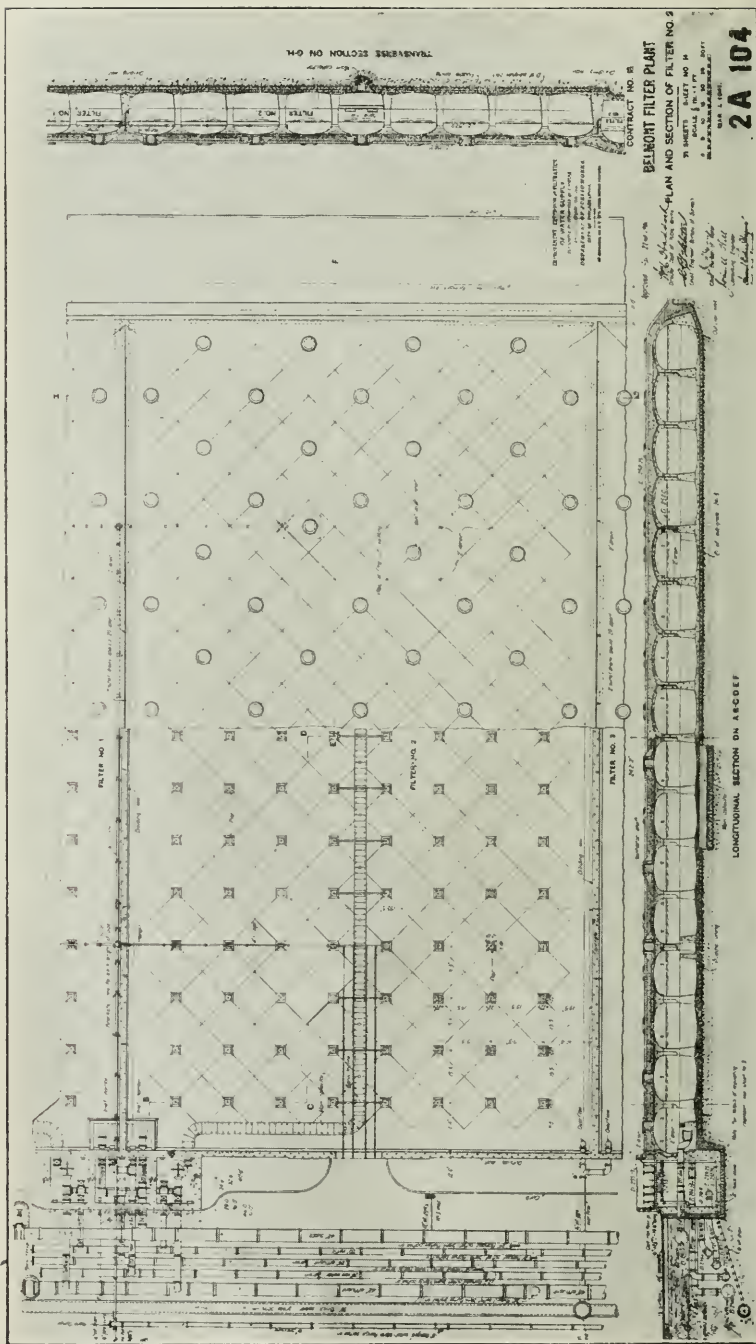


FIG. 13.—Plan and section of typical filter.

Difference of water surface between the highest and lowest filter, six feet.

Since the level of water in the clear-water basin (for any system of terraced filters) must be adjusted to the flow-line of the lowest filters of the series, the apparent loss of head at Belmont is six feet; but to attempt the placing of all filters at a common elevation would have required the raising of the fills under the filters at the lower levels, the materials for which could conveniently be obtained only from the excavation for filters at the higher levels, and the resulting common level of water surface in all filters would have been only about three feet higher than the water-level in the lowest level filter of the present series. This, therefore, is the true loss of head, against which the water is pumped from the Schuylkill River by reason of the terraced arrangement of filters at Belmont. That is to say, if all filters had been arranged at common water elevation, 251.33 C.D., the flow-line of the sedimentation reservoir might have been made 276.00 C.D., instead of 279.00 C.D.; but the fixed charges on the increased cost of construction to accomplish this were found to be much greater than the annual cost of pumping against the additional three feet head.

The plain sand filter at Belmont, as shown by *Fig. 13*, is in plan a rectangle with a net area at the sand line of 0.735 acre.

By the longitudinal section through the filter it will be seen that the roof arches are carried on monolithic concrete piers 30 inches square at the base and 22 inches square at the top of the battered portion of the pier. The battered section reaches to the proposed normal sand line. The side and end walls have a width at base of 4 feet 2 inches, and at spring line of arch a width of 1 foot 10 inches. Division walls have the same dimensions in thickness as the piers.

The floors consist of concrete inverts 15 feet 3 inches square, having a thickness of 6 inches at the center and of 14 inches under the piers. The vaulting of concrete is 6 inches thick at the crown, and normal to the arch curve about 15 inches thick at the spring line. The piers are 9 feet 1 inch high, the rise or depth of arch of floor inverts at

center 8 inches, and rise of roof-arch at center 36 inches, making a total height from center of invert to center of soffit of arch 12 feet 9 inches. The clear span of roof-arches is 15 feet 5 inches.

Under the floors and against the side and end walls of the filters, taken in groups of two, four, and six, clay puddle is placed as shown. The floor puddle was placed and rolled in two separate layers, each of 6 inches thickness when rolled in place. The puddle around the filters was carried 1 foot higher than the nominal water line in the filters, and rammed in layers of from 4 to 6 inches in thickness. (The value of the puddle as a means of insuring watertightness of the filters will be shown hereafter.)

The end walls of all filters, and side walls of the end filters, were designed as abutments to transmit the arch thrust to the foundations.

Each alternate bay of the filter is provided in the roof-arch with a round ventilator opening 36 inches in diameter. This is closed with a double iron plate cover, forming an air space between the two plates to prevent the frost from acting on the water or on the bared sandbed while it is being scraped in winter. In summer time it is desirable to have some of the ventilators open to prevent the air in the filters from becoming musty by the decomposing sewage solids intercepted at the surface of the sandbed. With open filters the musty condition of the air over and around the filters is not noticed, but with closed filters, excepting ventilation is provided, the air over the water becomes saturated with the gases of decomposition of sewage solids intercepted at the surface of the sandbeds, and ventilation is a necessity for the comfort and possibly for the health of the men required to enter the filters for scraping and removal of the fouled sand.

Over the arches of the filters at the crown a layer of 24 inches of earth is placed to protect the water and sandbed, when laid bare, from frost in the winter and to protect the water from the sun's rays in summer. At the depressions in the arches over the piers is placed gravel or ballast to act as a "French" drain and collect the water from rainfall which

may percolate through the earth filling over the vaulting and pass it down to the filter through the opening left in the haunch of the arch. The upper surface of the earth filling is finished with a dressing of top soil and seeded. In due time the surface of the fill will have a turf which, if kept properly watered and trimmed, will make a pleasing feature of the landscape.

Six lines of cast-iron waterpipe are shown to the left of the filter, arranged as follows :

Influent pipe to supply water to the filters.

Effluent pipe to conduct away the filtered water.

Refill pipe to refill filters from below with filtered water after scraping the sandbed.

Raw-water drain pipe to draw off the water from above the sand line.

Drain pipe to draw off the water from below the sandbed and conduct it to the sewer.

High-pressure pipe to supply water to the sand ejectors, and also to the sand washers in the courts.

In addition to the cast-iron pipes enumerated a 36-inch circular brick sewer, for waste water from the filters, and from the sand washers, and storm water collected on the courts, is also shown.

At Belmont (with the exception of two filters) the regulator houses are arranged each to serve two adjacent filters. (See *Fig. 14.*) The well or chamber under the regulator house is divided into a middle dry chamber and two side wet chambers. In the middle chamber are placed the pipes, stop-valves, and special castings, which connect the main influent and high-pressure pipes with the filters, the raw water drain to remove the water from above the sand line, and, as shown, near the bottom of the chamber, the main effluent pipes, which originate in the side chambers, and are brought together into a tee at the center of the dry chamber. The influent and effluent pipes for each filter are provided with stop-valves to cut either out of service without interfering with the adjacent filter.

In the wet chambers are placed the effluent pipes, drain-pipes to remove the water from below the sandbed and

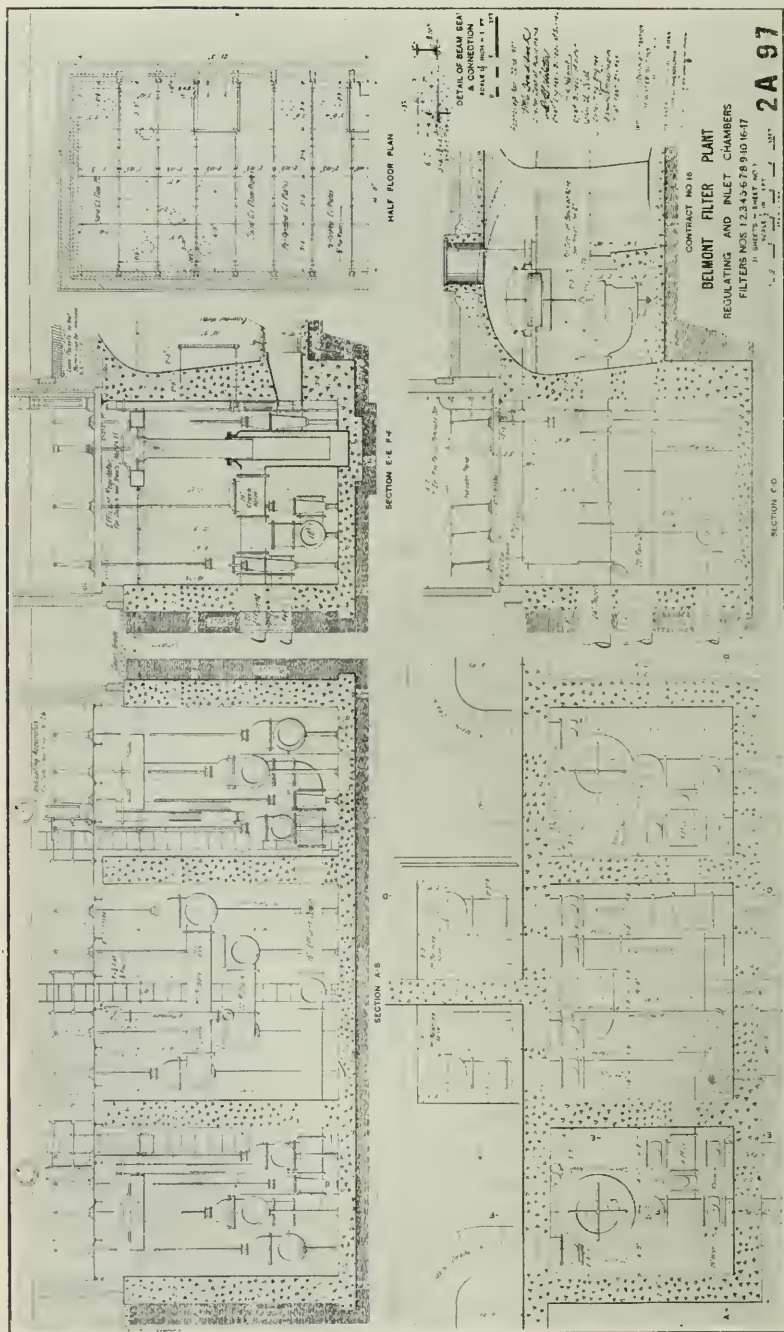


FIG. 14.—Influent and effluent chambers.

waste it to the sewer, and the re-fill pipe to supply water to the filter from below upon starting after a filter has been scraped.

Upon the main effluent pipe where it starts in the wet chamber, is placed an automatic telescoping circular weir, controlled in position with reference to the surface of the water in the chamber, by an annular copper float. This self-adjusting weir (which has its counterpart in the effluent chambers of the filters at Warsaw, Zurich, Bremen, and other places abroad) has its lip fixed at a definite depth below the surface of the water, and is not only an effective device to maintain a constant rate of flow of water from the filters, but when properly standardized becomes a reasonably accurate meter for the measurement of the flow.

The relation of the lip of the weir to the position of the float is adjustable, and it thus can be varied to produce any desired rate of percolation through the filter.

In the early form of the effluent weir the telescoping joint was made with a water-packed bronze gland; but experience at Roxborough has shown that it is impossible to produce drawn-brass pipes, 20 inches in diameter, so round or uniform in diameter as to admit of the use of the packing shown, and a leather packing, which will readily adjust itself to the eccentricity of the sliding tube and to the inequalities of diameter, has been substituted for the internally grooved bronze ring. The leather packings have worked admirably on the effluent regulators of the Roxborough filters, and, with the weir floating upon a constantly declining water surface, maintain, when adjusted, a practically unvarying rate of discharge from the filters.

Some trouble has been experienced from the air which is drawn into the column of water descending the telescoping pipe, and to remedy this defect in the construction of the regulators the necks at the top of the fixed barrels of the regulators are being tapped and provided with pipes reaching to a few inches above the highest possible water level in the effluent chamber, to vent the air from the regulator barrel. A test of one of these air-vents at Upper Roxborough

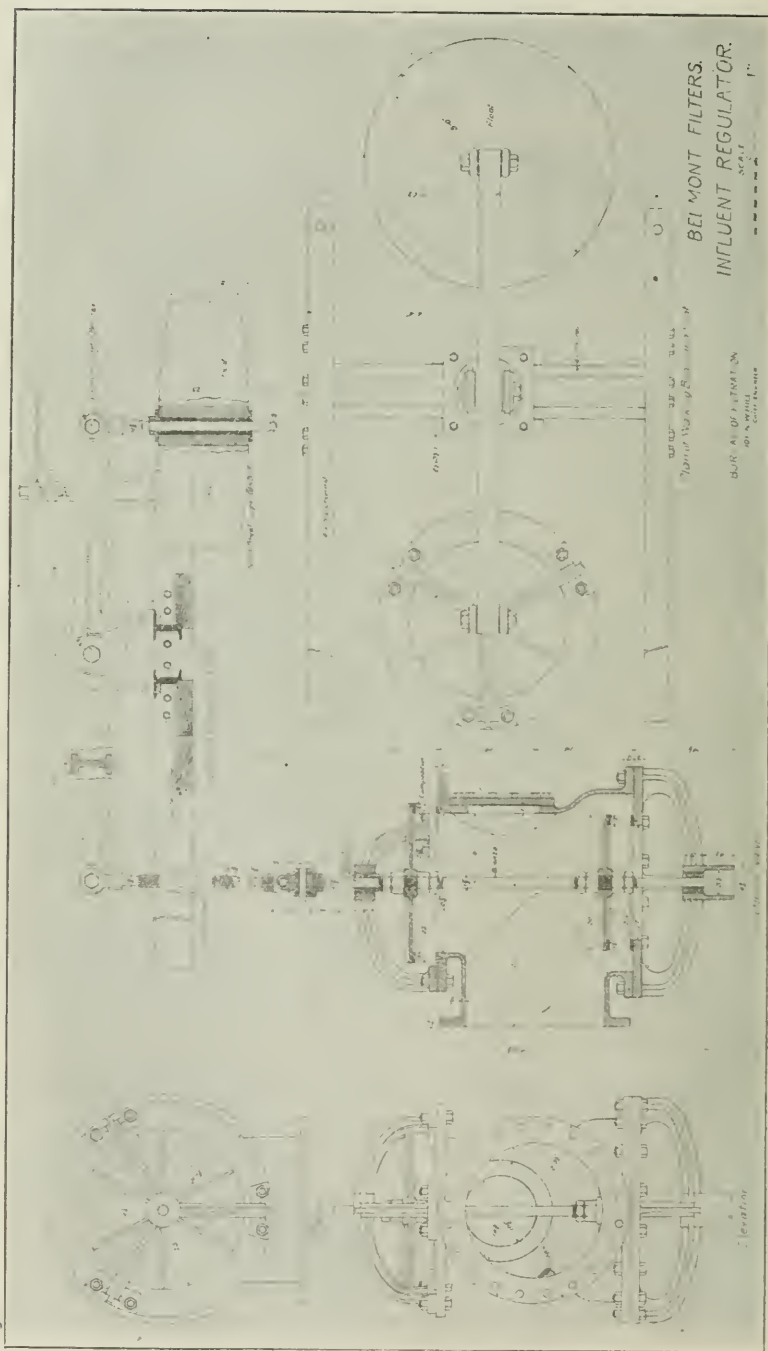


FIG. 15.—Automatic influent regulator.

seems to indicate that the trouble due to induction of air by the annular column of water flowing over the lip of the weir and down the telescoping pipe will be avoided in this manner.

The sleeve, or jacket-pipe, outside the telescoping pipe is used to prevent the current of water flowing from the regulator from having a tendency to draw the telescoping pipe from its central position, and cause it to bind in the packed joint.

Inside the filter on the end of the branch from the influent main is placed an influent regulator (*Fig. 15*) to automatically maintain a constant depth of water over the sand-bed. This consists of a plain double-seat disc-valve, nearly balanced, actuated by a cylindrical copper float. By the rise and fall of the float on the water in the filter the valve is closed or opened and the rate of inflow of raw water maintained nearly constant. This valve is in all material respects a copy of the influent regulators used on the Hamburg filters.

[*To be continued.*]

USE OF PEAT GAS IN IRON MAKING.

The use of peat gas for fuel purposes is of long standing in the iron and steel industry of Sweden, in which it is preferred to coal gas, on account of its much greater freedom from sulphur and phosphorus. At the rolling mills peat gas is used in the plate furnaces with the result of reducing the formation of scale, particularly in rolling thin steel plates. The use of peat gas has contributed largely to improving the quality of Swedish steel.

Peat, like wood, particularly green wood, is naturally suited, on account of its large percentage of moisture, to steady production of mixed gas, rather than to the alternate generation of first water-gas and then producer-gas, as with dry fuels such as coal.

POLONIUM.

Mme. Curie, the discoverer of polonium, maintains that it is not yet decided whether polonium is an element or not. The supposition that any radio-active substance which has different properties from other radio active substances is a separate element was verified in the case of radium, but is rendered uncertain by the phenomena of induced radio-activity. The case of polonium is rendered doubtful by the fact that the spectrum shows only the rays

of bismuth. On the other hand, it is possible to concentrate the radio-active substance contained in "radio-active bismuth," and this would not be possible if bismuth alone were present. Also, on sublimating bismuth sulphide, the sublimated portion is the more radio-active. It is possible that polonium does not possess any sensitive spectroscopic reaction. A serious point is the gradual loss of activity, which in one case amounted to 50 per cent. in eleven months. But Marckwald has succeeded in obtaining a polonium preparation which does not show any sensible loss. It would be interesting to determine the atomic weight of the element, and this the authoress is working at whenever she has a sufficient quantity of radio-active bismuth available.—*Physikal. Zeitschr.*

HIGH-SPEED ELECTRIC TRACTION.

The *Electrical World* has the following comments on the recent trials at Zossen :

Each new week sees a new record made at Zossen, in high-speed traction. We now have to note that a speed of $130\frac{1}{2}$ miles an hour has been attained since this paper last went to press, and even that may have been excelled before our comment gets into type. Just how long our German friends are going to keep this up we do not know, but it is safe to infer that they are still after that 150 miles an hour, which has been mentioned as their latest objective goal. At any rate, all that they have accomplished is vastly to their credit, even if they did not add another inch to their speed.

All this, moreover, is no idle *tour de force*. It has been supposed or suggested that the main idea was to get a method of transporting troops swiftly; but we ventured to intimate quietly some weeks ago that a new commercial road from Berlin to Hamburg might be found awaiting creation for high-speed purposes, after some of these problems had been solved. Confirmation of such a forecast is found in a cable dispatch this week from Germany stating that an electric road is to be equipped between Hamburg and Berlin, to operate at 100 miles an hour, and that the Emperor himself is deeply interested in the execution of the project. It is said, also, that this may be the first in a network of such roads covering the empire. We take the distance between Hamburg and Berlin to be somewhat over 150 miles, and this will be made in one and a-half hours on the new schedule. The carrying out of such a plan will be watched with deep interest in America, for we, with our vast stretches separating big centers of population, trying to get into closer touch all the time, have a great stake in the success of enterprises of this character. As to the suggested "network" of such roads, that is undoubtedly a very "large order" for the present stage of development. Many questions have still to be studied, not the least of which are the signaling on the technical side, and the profitable schedule on the commercial side. But there is some consolation in knowing that the limit of speed in transportation has been advanced and that humanity is not restricted forever to the jog-trot of the present steam régime with an average far below 50 miles an hour.

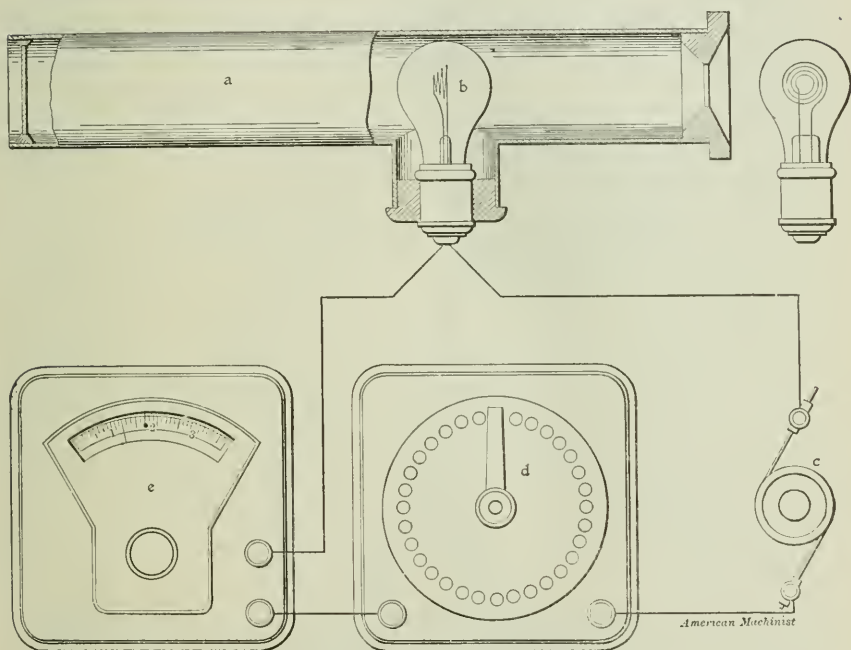
The Morse Heat Gauge.

[*Being the Report of the Committee on Science and the Arts on the invention of Everett F. Morse.*

Sub-Committee: G. H. Clamer, Chairman, James Christie, John M. Hartman, W. D. Harris.]

[No. 2240.]

The Franklin Institute, acting through its Committee on Science and the Arts, investigating the merits of the heat



Diagrammatic representation of Heat Gauge.

gauge, invented by Everett F. Morse, of Trumansburg, N. Y., reports as follows:

Pyrometry is the term applied to measurement of high temperature such as cannot be determined by the ordinary thermometer. There have been many methods proposed for the measurement of such elevated temperatures, and a number of quite satisfactory instruments designed. The

importance of pyrometric determinations is daily increasing, and the field of usefulness of a good heat gauge is an extensive one indeed.

Pyrometers have been made which depend on the method of mixtures, otherwise known as calorimeters, the principle of which is too well known to need description. Some have depended on the expansion of metallic strips or rods, and Messrs. Valy and Schorley employed a fluid alloy of sodium and potassium with mercury in a hard-glass tube by which means a temperature up to 600° C. could be read, as on an ordinary thermometer.

Carl Barus has given a classification of the principles on which pyrometers have been constructed. This appeared in the "Bulletin of the United States Geological Survey No. 54," 1889 :

- | | |
|--|----------------------------------|
| 1. Dilatation of solids— | 7. Ebullition. |
| (a) A single solid. | 8. Specific heat. |
| (b) Two solids acting differentially. | 9. Heat conduction. |
| 2. Dilatation of liquids— | 10. Heat radiation. |
| 3. Dilatation of gases— | 11. Viscosity— |
| (a) Expansion measured in volume, manometrically. | (a) Of solids. |
| (b) Expansion measured in pressures, manometrically. | (b) Of liquids. |
| (c) Expansion measured in volume by displacement. | (c) Of gases. |
| 4. Vapor tension. | 12. Spectrophotometry and color. |
| 5. Dissociation. | Rotary polarization. |
| 6. Fusion. | 13. Acoustics (wave length). |
| | 14. Thermo-electrics. |
| | 15. Electrical resistance. |
| | 16. Magnetic moment. |
| | 17. Miscellaneous. |

The above classification shows that almost every form of thermal phenomenon has been utilized for pyrometers. Probably the most important in practical application, because of its simplicity, is the method of fusion, viz., by means of various metals which, when brought into a heated atmosphere, or in the vicinity of a heated body, will melt, the melting point being known; thus a temperature which will melt one alloy and not another can be said to lie between the two. This, of course, gives but approximate results inside of a wide range, and hence is limited in its usefulness.



Heat Gauge as used with a blacksmith's fire.

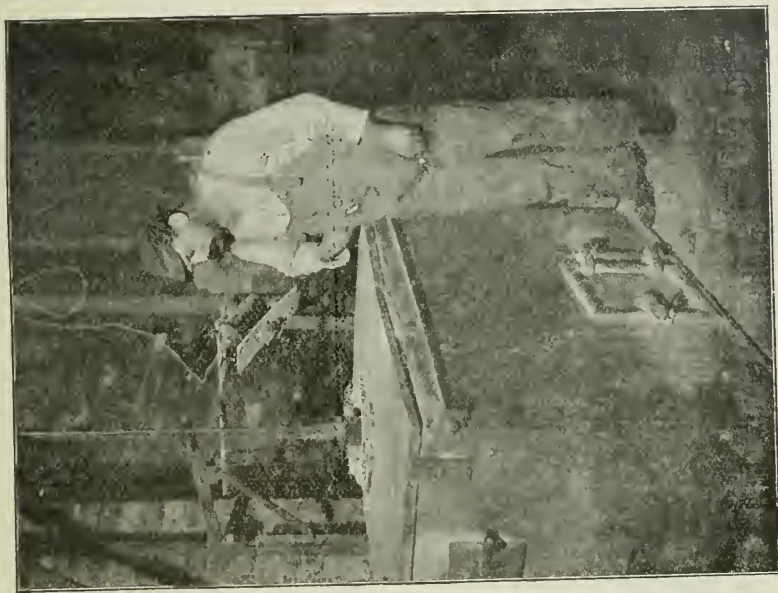
The most important application of this method has been in the determination of temperature of hot blasts in connection with blast-furnace practice.

Quite a satisfactory pyrometer is built on the principle that if a current of water of known temperature be allowed to run through a coiled tube, the temperature of the out-flowing water will be proportionate to the temperature through which it has passed.

An important advance was made with pyrometric construction when Sir Wm. Siemens discovered that an instrument could be made to gauge temperatures quite accurately, by comparing the resistance of platinum wire at ordinary temperatures with the same at an elevated degree. The method used being to pass a current through a platinum wire around about a porcelain tube, balancing the resistance by means of another coil, so that equal currents would pass through both. The platinum wire when placed in the heated medium is increased in resistance—the smaller current traversing it. This current, compared with that passing through the standard coil, is reduced to temperatures recorded on a table. Other instruments have been produced which depend upon the electrical resistance of bodies at elevated temperatures, notably the one of Professor LeChâtelier, which consists of a thermo-couple composed of platinum and an alloy of platinum with 10 per cent. rhodium. Such a couple, under the effects of heat, is capable of generating a current which can be measured on a sensitive galvanometer. The galvanometer in practice is standardized for direct reading of temperature. This pyrometer is very extensively used at the present time, and your chairman has had some experience with this apparatus in the measurement of the temperature of molten metals. This instrument is very trustworthy for the measurement of furnace chambers, etc.; but, owing to the thick walls of clay, or infusible material, with which it is necessary to protect a thermo-couple, takes a long while to produce a variation. A further difficulty lies in the inability to produce a clay protection which is substantial enough to make the instrument successful in the hands of any but a careful operator, and is entirely too deli-



Heat Gauge as used with a heating furnace.



Heat Gauge as used with a lead bath.

cate a contrivance for every-day use in the foundry. It was on this account that its use was abandoned.

Other pyrometers have been produced, of which the Morse gauge is a type, known as "optical pyrometers." In this, the eye of the workman, supplemented by an instrument which enables him to record the intensity of the radiations, becomes a pyrometer, so that the old method of judging temperatures by the appearance of the same is rendered comparatively accurate, and familiar indications of bright redness, etc., are subjected to direct measurements.

The optical pyrometer of LeChatelier is a photometric instrument. In this apparatus the rays emitted from a standard are compared with the rays emitted from a heated body whose temperature is to be determined. A red glass is interposed in the eye-piece and only red rays enter the eye. The photometer depends upon the adjustment to the same brightness of two images, one of the standard and the other of the compared body. The adjustment is made by means of two diaphragms having V-shaped notches opposite one another. They are operated by means of a milled head, and the light admitted depends upon their respective distance from one another. The measurement of this distance compared with the distance apart when observing the standard light is reduced to temperature.

Other optical instruments have been put upon the market, but the one under consideration is perhaps the most ingenious invention, because of its simplicity.

The invention of Everett F. Morse is covered by two patents, granted April 1, 1902, the first covering the process, and the second the method of gauging the temperature by heated substances. First, No. 696,619, and the second, No. 696,878.

The methods of optical pyrometry employed previous to the invention of Mr. Morse are unreliable, chiefly because the optical standards for comparison have been placed to one side of the compared, and consequently such comparisons are greatly dependent upon the personal equation of the observer.

The gist of Mr. Morse's invention is best stated in the

first patent, viz.: The method of gauging the temperature of a material which becomes incandescent when heated, consists in comparing said material, heated to luminous state, with an optical standard so that at least a portion of one is in the path of the rays passing from the other to the eye observing the standard and material and noting when the one immerses in the other to such a degree as to indicate the correct temperature within the necessary limits.

The apparatus of Mr. Morse consists first of a standard and by preference he has chosen the simple incandescent lamp, the temperature or color of which can be regulated by resistance, and the amount of current passing through the circuit recorded on a mill-ampere meter. This makes a very convenient and reliable standard. The lamp is enclosed in a tube which may or may not be open at both ends as desired. The tube containing the standard is held in such a position that the rays passing through the object of comparison will be superposed by the rays from the glowing lamp, the color intensity of which is regulated by means of the resistance in the circuit, that it will be of the same intensity, and will apparently be obliterated from view. At this point an observation of the ammeter and a comparison with the table, the result of calibration by means of a LeChatelier pyrometer, gives the ampere reading direct in temperatures.

The Morse Gauge is an exceedingly simple and practical device founded on good scientific principles, and should have a wide field of usefulness, especially in the study of that important question, the heat treatment of steel. It has been used by a number of prominent manufacturers for some time, whose testimonials form a part of the Committee's records.

In view of the novelty of the invention and its practical advantages over other apparatus and methods, the Institute recommends the award of the John Scott Legacy Premium and Medal to Everett F. Morse.

Adopted at the stated meeting of the Committee on Science and the Arts, June 10, 1902.

Attest: WM. H. WAHL, *Secretary.*

WASTE OF NATURAL GAS.

The reckless waste of the natural gas supplies of Pennsylvania, Ohio and Indiana is one of the greatest economic crimes committed in this country. Millions upon millions of feet of this ideal fuel were not utilized at all, and other millions of feet were burnt in huge flambeaux to advertise town sites.—*Engineering and Mining Journal*.

VANADIUM STEEL.

Metallurgic circles, especially abroad, have been interested recently in the singular properties of vanadium steel.

It appears that when from 3 to 5 parts per 1,000 of this metal, which is as yet very little known, are added to steel, it communicates remarkable properties.

Properly speaking, vanadium does not bestow on iron or steel any new property, but it doubles the coefficients of resistance to fracture under all circumstances (shock, crushing, elongation, etc.), and at the same time imparts such extreme hardness as to render it possible to reduce almost by half the thickness of the armor for vessels.

It is difficult to comprehend that the presence of from $\frac{1}{3}$ to $\frac{1}{2}$ per cent. of any element whatever in an iron alloy can have so intense and general an effect, though this effect is perhaps explained by the extreme avidity which under certain circumstances vanadium has for oxygen. This avidity might account for the fact that the presence of even the slightest quantities of vanadium in a bath of steel in fusion would lead to the immediate and absolute reduction of every trace of iron oxide still existing in the mass; now to these traces of oxide, which are inevitable without vanadium, the rupture of the best prepared steels is attributed. Crystals, even microscopic, of oxides would act like the stroke of a diamond on the thickest glass.

A peculiar property of vanadium steels is that they acquire their maximum of hardness, not by tempering, but by annealing at from 700° to 800° C. This has various consequences; for instance, a planing machine whose cutter is of vanadium steel is set at work with the greatest velocity and power. Soon the implement becomes heated, and even when it attains red heat, it still continues to take off shavings of iron or castings without exhibiting any exhaustion. It is almost unnecessary to remark that in such a case a cutter of ordinary steel would become completely softened and lose its cutting power.

This property is of particular importance for projectiles. It is known that the shock which they experience on striking the target raises them to an elevated temperature. If, by means of vanadium, this temperature does not diminish the hardness of their points, and consequently all their sharpness, is preserved, the penetrating force will remain intact.

The applications of vanadium may be numerous. It is said that they may cause a revolution in armaments. Incidentally, they would allow the construction of helmets and breast-plates, light and efficacious.

Vanadium has been valued as high as 130,000 francs per kilogram. It is now, we think, worth about 150 francs.—*L'Echo des Mines et de la Metallurgie*.

CHEMICAL SECTION.

*Stated Meeting, held Thursday, November 5, 1903.*Fermentation without Yeast Cells: A Résumé of
Buchner's Work.*

BY ROBERT H. BRADBURY.

I. HISTORICAL.

When fruit-juices or sugar-solutions are exposed to the air, the phenomena of fermentation gradually appear. A gas is evolved, the clear solution becomes turbid and a precipitate called yeast makes its appearance. At the same time, the liquid loses its sweet taste and acquires an alcoholic flavor and intoxicating properties. These observations are very ancient; fermented drinks have been prepared since the earliest times; but it is only since Lavoisier that it has been known that the chemical change is chiefly the separation of sugar into carbon dioxide and alcohol.

The rôle of the yeast long remained obscure. It was known that fruit-juices could be preserved if boiled and sealed up still hot; but this was ascribed to the absence of oxygen in the vessel. Leuwenhoek had ascertained in 1680 with the microscope the spherical or ellipsoidal shape of the individual constituents of yeast; but, instead of considering this a proof of organized structure, had regarded the substance as merely an albuminous precipitate, and compared the cells to starch granules. But in 1835-37 Cagniard de Latour and Theodor Schwann almost simultaneously made an important advance. The growth of the yeast was studied and its status as a living plant placed beyond doubt. It was shown that fruit-juices could be pre-

* Buchner has recently published a connected account of his researches (*Die Zymasegärung*, 1903). Those who wish to familiarize themselves with the revolutionary change which has been brought about in our views of fermentation, will find this book authoritative, fascinating and complete. It has been very freely used in the preparation of the present paper.

served by the boiling process even when there was a large supply of oxygen in the sealed vessel. Fermentation does not occur even when air is allowed access to the boiled juice, provided that the air has previously passed through a red-hot tube, or bubbled through strong sulphuric acid. On the other hand, the admission of ordinary air immediately causes fermentation and organisms simultaneously appear in the liquid.

Upon this basis was erected the "*vitalistic theory of fermentation*," according to which the cause of the phenomena is the life-processes of the yeast plant. Schwann assigned to the sugar the rôle of nutriment and to the alcohol and carbon dioxide that of excretion-products. This view was bitterly opposed by the chemists of the period, Liebig at their head. It is not remarkable that just after Wöhler's synthesis had dethroned the "vital principle" in organic chemistry chemists should object to converting what had been regarded as a chemical process into a vital act. Berzelius had already (1828) suggested that the action of the yeast was catalytic, and Liebig developed this idea into his "decomposition theory." He regarded the yeast as a body engaged in active putrefaction in the presence of which sugar became infected with the same change, just as a rotten apple may contaminate a good one, or a little soured wine produce a rapid transformation of good wine to vinegar under favorable conditions. This ill-defined conception had no experimental evidence in its favor. Dead and decaying yeast might have been regarded from this point of view—hardly the living, growing plant. But Liebig's influence was so immense that the idea held its ground until routed by the decisive experiments of Louis Pasteur, who proved in the most complete way that no putrefaction of the yeast occurs during fermentation; that the process depends upon the life of the yeast-cells, not upon their death, and that fermentation can occur in the entire absence of decomposing albuminous materials. The function of air in exciting fermentation in sterilized liquids he cleared up by filtering air through collodion wool, dissolving in alcoholic ether and examining the residue with the microscope. It was found

to consist of the same organisms which are present in fermenting liquids. The destruction of Liebig's theory was completed by the proof that substances engaged in active decomposition, like hydrogen peroxide or a warm solution of ammonium nitrite, did not arouse fermentation.

Thus the vitalistic theory remained in complete possession of the field. But the mere fact that fermentation had never been observed in the absence of organisms does not prove that it is due to the life-processes of the yeast plant. There is an alternative possibility—that the cell contains a substance which acts catalytically on the sugar and brings about the transformation. This is the *enzyme theory*, stated by Moritz Traube in 1858, and that Pasteur himself believed in its possibility is shown by the fact that he made repeated unsuccessful attempts to extract the active substance from the cells by grinding them in a mortar, by freezing and then thawing—the idea being that the cell-wall might thus be burst and allow the contents to escape, and by immersing them in strong saline solutions so as to force the contents through the cell-walls by osmosis.

II. ENZYMES IN GENERAL.

So far enzymes have been obtained only from plants and animals; it has not been possible to prepare them artificially. Most of them are to be regarded as albuminoids, but not all, for some seem to be very low in nitrogen or even to be free from it. They are produced directly from the living protoplasm, and many of them are similar to it in chemical character but not identical with it. They stand on the boundary between living and dead matter, but are not to be considered as living, for the characteristic signs of life, assimilation, reproduction and the organized structure, are lacking. Their extraordinary instability and chemical activity cannot be viewed as evidence of life, for there are substances like colloidal platinum and the diazo-compounds which share these peculiarities. The enzymes are soluble in water and the solution passes through a filter of biscuit-porcelain, by which all bacteria are stopped. A dissolved living organism is unthinkable. The chemical constitution of the enzymes

is extremely complex and they are probably all asymmetric in configuration. This is a natural assumption, since they are complex products of the organism and the different action of some enzymes on enantiomorphous sugars is only explicable on the ground of asymmetry in the enzyme itself.

The enzymes appear to take no part in the chemical changes which they bring about. They are found unaltered after the reaction and are able to produce a transformation which is quantitatively entirely disproportionate to the amount of the enzyme present. In this respect, as Berzelius recognized, their behavior is entirely analogous to that of other substances acting catalytically. Among inorganic catalyzers, especially the colloidal solutions of metals like platinum, show striking analogies with the enzymes. This is interesting because it shows that the chemical activity is very possibly connected with the huge surface-development of a substance held in colloidal solution. The solutions of the enzymes are also colloidal.

III. THE EXTRACTION OF THE CONTENTS OF THE YEAST-CELL.

The cell-wall of yeast is far too elastic to be ruptured by mere grinding in a mortar. But when yeast dried by compression is mixed with an equal weight of fine quartz-sand and one-third of its weight of infusorial earth and the mixture vigorously ground, the cell-walls are burst by the attrition of the quartz particles and their contents escape. At the same time, the mixture, which is at first a dry white powder, becomes moist, gray-brown and plastic. With 400 grams of the mixture this change takes place in less than five minutes. The mixture is then subjected to strong hydraulic pressure, and the cell-liquid escapes and is received in a vessel immersed in ice-water. The sand plays the chief rôle in bursting the cell; the object of the infusorial earth is to make the mixture less slimy, so that it supports pressure better and yields a clearer filtrate. Only a portion of the cells is opened in this operation. If anything like a complete extraction of the cell-contents is desired, the grinding must be repeated a number of times. In one experiment there were five repetitions of the grinding and compression,

and in all 700 cubic centimeters of cell-liquid were obtained. The last fraction showed strong fermenting action, and it was clear that the yeast was by no means exhausted.

The elasticity of the cell-wall explains the failure of Pasteur's attempt to extract the contents by freezing. When the liquid is frozen, the membrane is distended a little, but not burst, and upon thawing it remains intact. But if the yeast is *pulverized while frozen*, the cell is broken, and upon melting the contents escape. This is the explanation of the following experiment: When 500 grams of dry yeast are mixed with 500 grams of solid carbon dioxide and the mixture ground in a mortar, the mass, which is at first frozen to stony hardness, gradually becomes soft and semi liquid. Upon filtering with a pump, only 100 cubic centimeters of cell-liquid were obtained, but its fermenting power was energetic. This method has not been used much, owing to the expense, the small yield and the long grinding required.

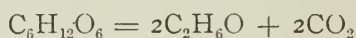
IV. THE PROPERTIES OF THE CELL-LIQUID.

The liquid obtained by either of the preceding methods is yellow or brownish-yellow and almost clear. It smells and tastes strongly of yeast. The reaction is acid, and this is not due to carbonic acid, for the acid reaction is not removed by evaporation to one-half volume in a vacuum. Addition of strong potassium hydroxide, of mineral acids, or of acetic acid, causes such a copious coagulation of albumin that the whole mass often becomes solid. The same thing happens when the liquid is boiled. If it is only warmed gently (50°), the coagulation is slight, but the fermenting power disappears. Upon preservation, the fermenting power of the liquid is soon lost, and then, when it is boiled, the coagulation is much diminished, or does not take place at all. This loss of activity is rapid at ordinary temperatures, but even in a refrigerator it is very noticeable in one day, and complete in two or three.

V. ACELLULAR FERMENTATION.

When sugar is dissolved in the liquid, or a strong sugar-solution added to it, the phenomena of fermentation mani-

fest themselves almost at once—so rapidly that is possible to show the process as a lecture-experiment. Thus in one experiment in which 100 cubic centimeters of cell-liquid were mixed with sugar; 6 cubic centimeters of gas were evolved in the first fifteen minutes; in another similar experiment, 6.5 cubic centimeters of gas in the same time. This gas is pure carbon dioxide, for it renders lime-water turbid, and when collected over mercury is completely absorbed, if a little solution of caustic potash is admitted to the tube. The process has been followed quantitatively, and it has been shown that carbon dioxide and alcohol are produced in approximately equal quantities. It will be remembered that this is also the case in ordinary yeast-fermentation as shown by the familiar equation, due to Gay Lussac:



In this respect, and in the considerable development of heat which occurs, acellular fermentation is similar to ordinary fermentation. But there are some important differences. Thus, the cell-liquid obtained by the methods just discussed, slowly ferments glycogen, dextrin and even starch, which is not the case with living yeast-cells. Again, yeast-cells act upon glucose more rapidly than upon fructose, so that a fermenting solution of invert-sugar gradually becomes more and more *lævo*-rotatory. But the cell-liquid ferments glucose and fructose with exactly the same speed, so that the volume of CO_2 , liberated in the two cases, is exactly the same after the same lapse of time. Of course, the same volume of cell-liquid was taken in the two experiments, and the same weight of glucose in one as of fructose in the other. The most probable explanation of this interesting fact is that glucose and fructose differ in the speed with which they diffuse through the cell-wall, and when the membrane is removed and the liquid acts directly upon the sugar the difference disappears.

It is well known that small quantities of glycerine and succinic acid are so constantly produced in ordinary fermentation that Pasteur regarded them as products of the process in the same sense as alcohol and carbon dioxide. Now

it is so difficult to estimate glycerine and succinic acid in such a mixture as the cell-liquid that Buchner does not regard his experiments as quite conclusive, but they indicate strongly that in the acellular fermentation these two substances are not produced at all. We shall have to regard them, therefore, as products of the nutrition of the cells, having no direct connection with the fermentation process.

VI. THE CAUSE OF FERMENTATION IN THE ABSENCE OF YEAST-CELLS.

The most important fact that emerges from the experimental results just stated is that the complex mechanism of the yeast-cell is not necessary for the fermentation process. The phenomena occur in its absence. But is this conclusion certain? Is it not possible that a sufficient number of cells have passed through the cloth of the hydraulic press and escaped the following filtration to account for the results? This objection seems serious, but it is easily met. The acellular fermentation is too rapid and energetic to be caused by the few hundreds of cells which could be present in the liquid. Millions would be necessary. More conclusive is the fact that the cell-liquid can be passed through a Berkefeldt filter and then through a Chamberland filter of biscuit porcelain without losing its fermenting power. This operation completely frees it from cells, as has been shown by bacteriological methods.

Driven from the conception that the yeast-cell is the active agent, the advocates of vitalistic views retired a little and took up a new position. True, fermentation occurs in the absence of the yeast-cell, but the protoplasm of the cell is still living. This escapes from the cell when the wall is broken and gets into the liquid. It is to the action of this living protoplasm upon the sugar that fermentation is due.

It is difficult to speak with proper moderation of an explanation which requires us to think of a "living liquid," soluble in water—of a "living" something which passes unchanged through filters impervious to all organisms—of a "living" substance which has no structure, no assimilation, and no reproduction. Anyone who advocates this view

should be required to explain exactly what he means by life, since it is clear that his conception of the term differs profoundly from that of normal men in general. We might as well regard the carbon dioxide of the lungs or the oxygen from plant-leaves as living.

This view may be dismissed as not possessing the definiteness which we have a right to demand of a scientific hypothesis. When, as in this case, a great step has been made in the separation of a complex phenomenon into its elements, the attempt to retain the old explanation by altering a definition is always futile and retrogressive. It may be worth while to mention a few facts which make the explanation—so far as it is capable of definite formulation—entirely inadmissible. Toluene in 1 per cent. solution entirely arrests the growth and fermenting action of yeast-cells, but does not interfere with acellular fermentation. We should have to assume, therefore, that after the removal of the cell-wall the naked living protoplasm becomes much less sensitive to the action of the toluene than it was before. The active agent in the cell liquid is precipitated as a white powder by adding a mixture of alcohol and ether. It can even be dissolved in water and the precipitation repeated without destroying the fermenting power. Yeast-cells are immediately killed by this treatment and it is impossible that living protoplasm should survive it.

When yeast-cells are killed by being soaked in acetone or in alcohol the vital functions of growth and assimilation cease, but the fermenting power remains, although the protoplasm is undoubtedly dead. In one experiment some of these *dead* cells were ground with quartz and infusorial earth and subjected to pressure just as previously described. The resulting liquid—which possessed a strong fermenting power—was precipitated by a mixture of alcohol and ether. The solid was dissolved in water to a clear light-brown liquid and again precipitated with alcohol and ether. The liquid produced by dissolving this final precipitate in water fermented sugar vigorously. A “living” liquid extracted from dead yeast-cells and passing still living through the treatment just described is simply unthinkable.

The experimental results, therefore, without any admixture of speculation amount to this: that the cell-liquid contains a substance which gives rise to that separation of the sugar-molecule which we call fermentation. This substance cannot be regarded as living, for it can be dissolved in water filtered through biscuit porcelain and precipitated again, dried and heated to over 100° without losing its activity. It is contained abundantly in dead yeast and can be extracted by exactly the same methods which apply to the living cells. In short, it behaves in exactly the same way as other unstable chemical compounds.

Now, the preceding paragraph—which contains nothing but pure fact from beginning to end—is simply a brief statement of the enzyme theory of fermentation. Moritz Traube's speculation has become a fact. Yeast contains an enzyme which is the active cause of alcoholic fermentation and the process must be classified with the other enzyme actions: it has been transferred from the domain of the biologist to that of the chemist.

VII. EXPERIMENTS DIRECTED TOWARD THE ISOLATION OF ZYMASE.

Buchner has given the name *zymase* to the enzyme of yeast, and has made many interesting experiments on its separation from the cell-liquid. That these attempts have not led to its preparation in pure condition is not surprising, for zymase, like all enzymes, is unstable, and the cell-liquid is a very complex mixture.

When the cell-liquid is simply frozen in a tall cylinder and then allowed to melt, it separates into two layers. The upper one is colorless, and consists mostly of water; the lower is red-brown, dense and ferments sugar much more intensely than the original liquid.

When the cell-liquid is allowed to fall into a mixture of alcohol and ether, a white precipitate is produced, which contains all the zymase. This is filtered at a pump and dried in a desiccator over sulphuric acid. It is a dry, white powder, which represents about 15 per cent. by weight of the original liquid. When 2 grams of it were mixed with

VOL. CLVII. No. 937.

sugar and water in a long tube, the fermentation was so energetic that in fifteen minutes the mass frothed over at the top. The powder can be dissolved in water and the precipitation by alcohol-ether, repeated without injury to the enzyme, if the operation is rapidly performed. Long contact with alcohol reduces or destroys the fermenting power.

However, the powder prepared by the preceding method is not pure zymase, or anything like it. In fact, it can be shown that, in all probability, the zymase is only a very small fraction of its mass. When cell-liquid is dropped into a small quantity of alcoholic ether, the albumins are precipitated, but not the zymase, so that the precipitate has no fermenting power. On the other hand, when a large quantity of alcoholic ether is employed, the zymase also precipitates. But when equal volumes of the cell-liquids are employed in the two experiments, the weight of the two precipitates is almost exactly the same, though one contains all the zymase and the other apparently contains none of it.*

Instead of alcoholic ether, acetone can be employed in this method, but its use offers no special advantage. Wood alcohol entirely destroys the enzyme, for both precipitate and filtrate are without action on sugar.

When the cell-liquid is carefully evaporated to dryness at 35° under reduced pressure, a yellowish powder is obtained, which has a pleasant odor of yeast and is completely soluble in water. This possesses all the fermenting power of the original liquid, and retains it unchanged for a year or more. Eight hours heating at 85° did not affect the activity.

VIII. DEAD YEAST.

Yeast is dried as far as possible by pressure, and slowly introduced through a sieve into a large quantity of acetone in a flat dish. The yeast is allowed to remain in the liquid ten minutes. It is then filtered and subjected to a second acetone treatment. Finally, the acetone is removed by

* It may be pointed out *en passant* that this experiment constitutes another disagreeable difficulty for the advocates of living protoplasm. They are forced to assume that the protoplasm is killed by a small quantity of alcoholic ether, but resists perfectly the action of a large quantity.

washing with a little ether, and the product heated to 45° for a time to drive off the ether. The result is a dry, white powder. It contains no living cells, for it is incapable of growth or reproduction, as has been shown by convincing experiments. Its fermenting action is intense. A tube half filled with a liquid containing 2 grams of dead yeast and 1 gram of sugar foamed over forty minutes after the beginning of the experiment. Dead yeast retains its activity almost unchanged for six months or more. All these facts are inexplicable by the hypothesis of living protoplasm, but they are natural consequences of the enzyme explanation.

IX. CONSEQUENCES.

The great result of Buchner's work is that the yeast-cell is non-essential to the fermentation process. Its only function is to produce and store up the zymase. Fermentation itself is a purely chemical process. We are now in a position to answer the old question whether fermentation takes place inside or outside the yeast-cell. Since the zymase never passes through the unbroken cell-wall the inside of the cell is the theatre of the process. The sugar goes to meet the enzyme by diffusion through the membrane and when we consider the speed with which fermentation progresses it is clear that the cell-membrane must be the seat of osmotic phenomena of exceptional intensity.

Zymase is the first example of a new class of enzymes—those which never leave the cell during its life. These may be called endo-enzymes. Most enzymes, when secreted, leave the cell and exert their chemical activity in an outside liquid. It will be observed that the cell loses some of its importance in biology as a result of this work. It seems that for every specific chemical act of the cell there is a specific enzyme which can do the same thing in the cell's absence. When the process of dissection and explanation of the cellular activities is finished what will remain as actual vital performance?

The scientific importance of Buchner's discovery is immense, but there is no prospect of any direct practical application. The synthesis of zymase, while a possibility,

is a very remote one, and in the meantime it is far simpler to employ yeast than to extract the cell-liquid and use it for fermentation. For in yeast new zymase is constantly produced, while in the cell-liquid or the precipitates made from it, this is impossible. Indirectly the practical results of the discovery will be of vast value. It points the way, for instance, to researches on the production of zymase in the yeast-cell, and the ascertainment of the most favorable conditions for the production and storing up of the enzyme would produce a revolution in fermentation technique. The attainment of this information is now perfectly possible and work directed toward it has already begun.

CENTRAL MANUAL TRAINING SCHOOL,
PHILADELPHIA, November, 1903.

THE PRODUCTION OF QUICKSILVER IN 1902.

The production of quicksilver in the United States during 1902, says Dr. Joseph Struthers in his report to the United States Geological Survey, amounted to 34,151 flasks of 76½ pounds each, valued at \$1,500,412, as compared with 29,727 flasks, valued at \$1,382,305, in 1901, an increase in quantity of 4,724 flasks and in value of \$118,107. California contributed the greater part of the output, amounting to 29,199 flasks, as compared with 26,720 flasks in 1901. Texas reported 5,252 flasks, as compared with 2,932 flasks in 1901, both States thus showing an increase in the production above that of the preceding year. Oregon, which furnished 75 flasks in 1901, reported no production during 1902, the quicksilver mining operations in that State being limited to development work.

The report contains a detailed review, by Mr. William Forstner, of the progress in quicksilver mining in California during 1902. As is well known, California has produced nearly the entire output of quicksilver in the United States, the quantity to be credited to that State since 1850 amounting to 1,913,258 flasks, of which the New Almaden mine, in Santa Clara County, has furnished more than 50 per cent.

The production of quicksilver in Texas during 1902, valued at \$228,620, as compared with a value of \$132,438 in 1901, shows a very active development of the industry. The entire output for both years was produced by the Marfa and Mariposa Mining Company, operating at Terlingua, Brewster County.

The exports of quicksilver for 1902 amounted to 13,247 flasks, valued at \$575,099, as compared with 11,219 flasks, valued at \$475,609, in 1901. Of the exports, 8,913 flasks, valued at \$383,578, went out of the port of San Francisco, nearly one-half going to Hongkong.

Section of Photography and Microscopy.

Stated Meeting, held Thursday, October 29, 1903.

Upon Changing Photographic Plates from the Developing to the Fixing Bath Without Recourse to the Dark-Room.

BY ARTHUR W. MCCURDY.
(Communicated.)

(1) Let a photographic plate, which has been exposed in a camera, be developed in the dark-room in the usual way.

(2) After development place the plate under a tap of running water until the developer is thoroughly washed off.

(3) Open up the dark-room to daylight and place the plate in the fixing bath.

Fixation, without fog, will be complete in about ten or fifteen minutes, according to the strength of the bath used.

I was led to the above experiment by the fact that dealers are using developing machines in the dark-room to develop films because of the increased ease and speed by which films can be handled with the machine. Instead of putting the fixing bath into the machine, they withdraw the film after washing, place it in a tray containing a fixing bath prepared for a great number of films, and immediately proceed to develop a new film.

It at once occurred to me that it would be very important to devise a method of development by which the amateur, who has no dark-room, might be enabled to attain the speed of the dealer who has a dark-room.

The following experiments, (a), (b), (c), led up to (d), previously mentioned.

(a) Submit an exposed plate to the action of the developer, wash and fix in the dark-room and the result will be a negative free from fog.

(b) Plunge an exposed plate, without development, into the fixing bath in daylight. After fixation the plate will be clear.

(c) Submit an exposed plate to the action of the developer in the dark-room, and in daylight, before washing, plunge it into the fixing bath. The plate will be fogged.

(d) Submit an exposed plate to the action of the developer, and, after washing off the developer in the dark-room, plunge the plate into the fixing bath in daylight. The negative will be found free from fog. (See *ante*.)

The developing machine is admirably adapted for just such an experiment. An exposed cartridge can be placed in it in daylight, can be developed in daylight, can be washed in daylight; and in daylight the carrier, black paper and film can be unrolled, the film torn off from the paper and immersed in the fixing bath, prepared for a number of films, in another dish. In such an experiment I have found the negative to be free from fog. Thorough washing after development, and before exposure to the light, is the *sine qua non*. To obtain thorough washing after development, place the machine under a tap of running water, rotate the film and frequently pour off the water until it runs clear.* Washing should be complete in about two minutes, and the machine be ready for the immediate development of another film.

Thus a method is pointed out by which the amateur, without a dark-room, may attain the speed of the dealer with a dark-room.

DISCUSSION.

MR. U. C. WANNER:—The paper of Mr. Arthur W. McCurdy, of Toronto, Canada, on the above subject suggested the following experiments:

I exposed four Bradley's "Extra-Speed" plates twenty seconds each at U. S. stop 128 on a dull, cloudy morning in October, between 7.30 and 7.50 A.M., and a fifth plate two seconds at the same time and stop. The first of the four plates was developed as an over-exposed plate with pyrogallic acid developer, and fixed in the usual way, in the dark.

The second was developed precisely like the first and when development was completed, was thoroughly rinsed

* In this experiment I used pyrogallic acid developer.

under the tap and exposed to gaslight for half an hour and then fixed in light. It was necessary to mark the plates to know which was fixed in the dark and which in the light. The third plate developed was the two-second exposure, treating it for under-exposure, after securing all the detail possible and developing the high lights almost to a harshness. I rinsed the plate thoroughly and exposed to gaslight for half an hour, then redeveloped the plate in a solution one-half the strength of the original until the entire surface of the plate was veiled that little detail could be seen in examination of plate by the ruby lamp. The plate was again thoroughly rinsed and exposed to gaslight for a considerable time, after which it was fixed in light.

The veiling of the film produced a much better printing negative than would have been possible without it in a plate so much under-exposed, by giving a better printing density to the entire negative, and especially to the shadows, without affecting the detail to any appreciable extent. This, of course, must be done with considerable care and judgment, as carrying the veiling too far would be at the sacrifice of brilliancy and detail; and again, this might be of use in securing diffusion or indistinctness for art purposes.

The fourth and fifth to be developed were treated precisely as the first and second, and, when development was complete, washed under the tap for a period not exceeding two minutes, after which they were dried in daylight. The fourth was fixed after being exposed to daylight an entire day, and the fifth was fixed before the Section of Photography and Microscopy on October 29, 1903, after two days' exposure to daylight.

There is no apparent difference in the resulting negatives from the plates of same exposure and development, and the under-exposure was very materially improved by the heroic treatment given it.

These experiments fully bear out the claims made by Mr. McCurdy, and the conclusion is that a plate or film, washed free from the reducing agent used in developing the image, may be fixed as well in the light as in the dark, and at the convenience of the operator.

METALLIC CALCIUM BY ELECTROLYSIS.

A problem that up to the present has stubbornly resisted all attempts at its solution, to wit, the electrolytic production of metallic calcium from lime, has at last yielded to the onward march of science. The triumph was accomplished in the Electro-Metallurgic Institute at Aix-la-Chapelle, by Professor Borchers and one of his engineering students, Herr Stoekem. The process employed is similar to that of the production of aluminum from beauxite, as described in the *Zeitschrift für Elektrochemie*. Aluminum, as is generally known, is separated out of a molten mixture of cryolite and alumina, and the process is even simpler, since only one material is submitted to electrolysis, calcium chloride, to wit, which melts at about 800° C. (1,475° F.).

Certain peculiarities of calcium, not possessed by aluminum, make special care in arranging the electrodes necessary, and even then many failures are encountered. Without entering into a history of the process employed by the professor and his pupil, we would say that the possession of a method of producing metallic calcium at will, easily and cheaply, is of great importance to chemistry, in its application to the arts and manufactures. It is not, of course, available for manufacturing vessels, implements or tools, and it does not keep when exposed to the atmosphere, but is converted by it into calcium oxide, quicklime. It is, as remarked, in the chemical industries that calcium will find its greatest usefulness, and especially in organic chemistry, where the need for a cheap metal, with powerful reducing properties, stronger than those of aluminum, magnesium, and zinc, and weaker than metallic sodium and potassium, has for a long time been felt.

The cost of metallic calcium—about \$22.50 per pound—has hitherto precluded its use in this capacity (*i. e.*, as a reducer), but, by the new process, this cost is lowered about 5,000 times, it being produced at the amazingly low rate of 45 cents per hundred weight—a fact whose importance to organic chemistry it is impossible to overestimate. Besides its importance in this direction, the discovery is of high interest to the iron industry. To free iron from phosphorus, sulphur and oxygen, an addition of aluminum to the molten ore has hitherto been necessary, and while a specimen of iron containing aluminum is better than one containing phosphorus, or sulphur or oxygen, it is not as good as absolutely pure iron as regards resistance to strain and fracture. Should the theory now maintained by experts that the amount of calcium necessary to reduce these deleterious contents be so small as to virtually leave the iron in a state of purity—should this be confirmed in actual practice, and should it be found that the calcium plays no deleterious part, the new industry of calcium producing has a most brilliant future. The same may be said for metallic strontium, which is now being produced cheaply and plentifully.—*Nat. Drug.*

ELECTRICAL SECTION.

Stated Meeting held Thursday, October 8, 1903.

Rail Bonds.

BY W. E. HARRINGTON.

General Manager Camden and Suburban Railway Company.

Rail-bonding is a subject that is usually regarded as simple, and therefore not requiring much detail attention by railway companies and engineers; to an extent this is true. The writer only proposes to treat the subject in a way to bring attention to the salient features, bonds and methods employed recently, testing, and to draw conclusions based largely upon experience.

The literature upon the subject of rail-bonding is not very extensive. Our available data and knowledge have been derived chiefly from the pen of manufacturers or inventors who have been financially interested in the bonds about which they have written.

The subject, however, is an exceedingly interesting one, and if railway companies and engineers who have to do with bonding would make a record of their observations and experiences great benefit generally would unquestionably be derived.

The form or design and cost of bond is of secondary importance, the two vital features always to be considered are,

A—Life	} Primary.
B—Conductivity	
C—Cost	} Secondary.
D—Design	

The life of a bond, and its value after a period of active use, must always be regarded as the most important item in making a determination as to the adoption of a bond. This can only be found either by experience of the user, or by consulting with others who have had experience. The value of the bond should not be lost sight of after it has served out its usefulness.

The conductivity of a bond is a quality that can so read-

ily be determined that no railway or engineer should adopt any form of bond until tests have been made and data established in reference thereto. It is manifestly unwise to adopt in the outset a bond whose conductivity makes the resistance around the rail joint higher than the corresponding length of solid rail section. Furthermore, tests should be made to determine the ratio of conductivity of joint to solid rail after the bond considered has been in actual service and use, for as long a period from which data can be obtained.

The cost of bonding represents so small a percentage of the total cost of the construction of a railway that this item need only be treated similarly to all other business propositions; for instance, if a railway from its knowledge of its service knows that a 100-pound T-rail is required, it proceeds to obtain the 100-pound rails on the most favorable terms possible, without any consideration of 50- or 60-pound rails.

The design of a bond is immaterial, providing positive knowledge is had as to its life and conductivity.

Poor bonding results in seriously affecting the proper and satisfactory operation of an electric railway. The following is a list of troubles incident to poor or incomplete bonding, the correction of any one of which, alone, would pay on any railway the entire cost of proper bonding:

A—Watt loss.

B—Depreciation of car electrical equipment.

C—Car service—loss in schedules.

D—Electrolysis.

The necessity of providing for the return of currents to power station by ample conductors and good bonded contacts goes without question.

Types of bonds now upon the market are generally in use, and methods of application are shown herewith and represent the best practice in the United States.

PROTECTED RAIL-BONDS.

The bonds are made of flat, parallel laid copper wires, formed into loops from one continuous strand. Pure

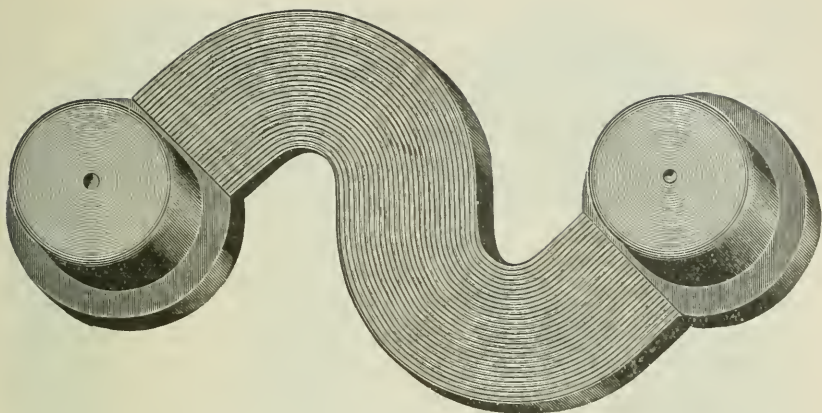


FIG. 1.—Type "C 3" protected bond (improved "S" bond), made extra flexible by the use of a large number of thin flat wires, all wires being of the same length. Maximum thickness, $\frac{1}{4}$ inch. Total depth, 2 inches.

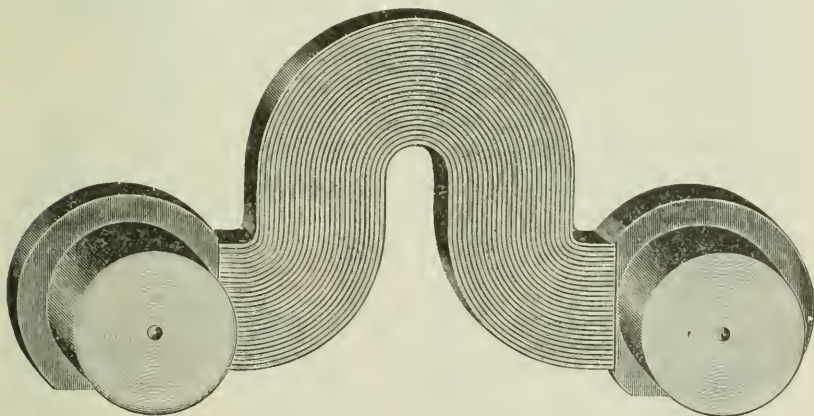


FIG. 2.—Type "B 3" protected bond (improved horseshoe bond), made extra flexible by the use of a large number of thin flat wires, all wires being of the same length. Maximum thickness, $\frac{1}{4}$ inch. Total depth, 2 inches.

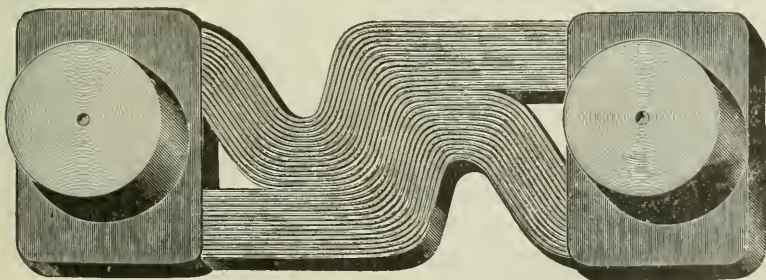


FIG. 3.—Type "E 3." Maximum thickness, $\frac{1}{4}$ -inch. Total depth, $1\frac{1}{4}$ inches.

copper terminals are fused on the ends of these loops and then forged to accurate size. The flat parallel-laid wires give great flexibility to vibration and the shape of the various types compensate for expansion and contraction of the rails without any direct strain on the strands or terminals. (See *Figs. 1 to 9.*)

Type "E 3," *Fig. 3*, protected bond (standard closed double-loop bond) is made extra flexible by the use of a large number of thin flat wires, all of the same length. It is in every respect the smallest practicable bond that can be made, and on account of its compact form can be applied practically to every section of rail and accompanying joint-plates now on the market. It is recommended for use in paved work only.

Type "F 3," *Fig. 4*, protected bond (improved open double-loop bond) is especially designed for use on joints where the inner joint bolts are too close together to allow of the use of a bond between them. For this bond the terminal holes are bored between the first and second bolts, the first bolt passing through the open loops near the ends of the bond. This provides an extremely flexible and durable electrical connection, and this type of bond is recommended for single bonding in preference to all others in joints where space allows it.

Type "G 3 U" protected bond, *Fig. 5*, is a special design of bond similar to type "G 3," except that the connecting strands are unequally divided by placing less number of wires on the top than on the bottom, as in types "F 3 U" and "H 3 U." It is used in double bonding joints where there is much less space above the joint bolts than below. With this type of bond the rail can be more readily bonded to full capacity.

Type "J 3" protected bond (special compound open-loop, tandem terminal bond), shown in *Fig. 6*, is a special large compound, double-loop bond having four terminals, and a cross-section of 425,000 C.M. It is made up of forty-eight thin, flat wires and has a maximum thickness of only $\frac{1}{4}$ inch. It is designed for application to girder rail laid in concrete with tie rods passing through at the joining of the rails. The middle aperture in the bond allows for the tie

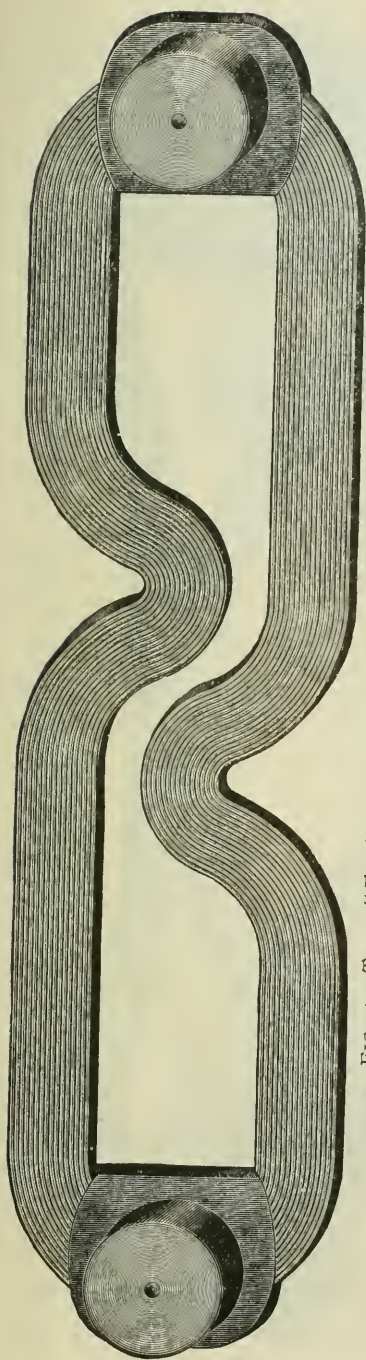


FIG. 4.—Type "F 3" protected bond. Maximum thickness, $\frac{1}{4}$ -inch.
Total depth for $\frac{3}{4}$ -inch bolt $1\frac{5}{8}$ inches. Total depth for 1-inch bolts $1\frac{7}{8}$ inches.

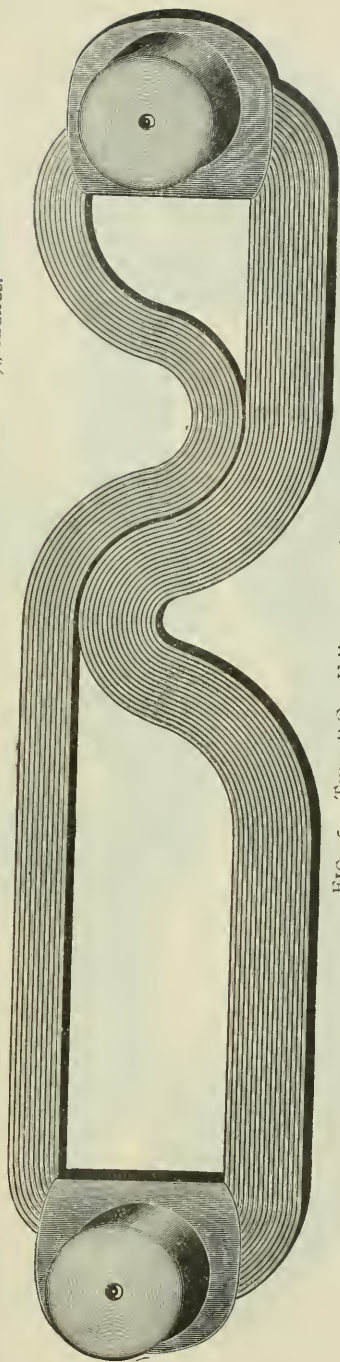


FIG. 5.—Type "G 3 U" protected bond.
Maximum thickness, $\frac{1}{4}$ inch. Total depth, according to the joint and capacity of bond.

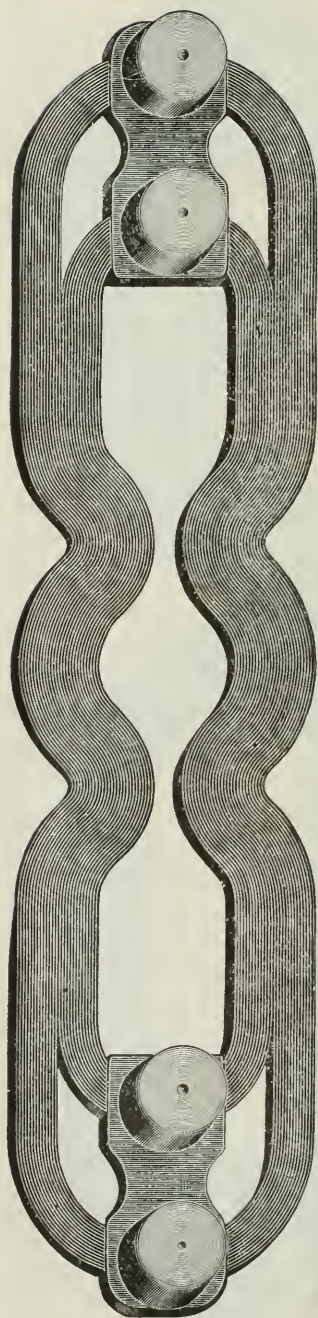


FIG. 6.—Type "J 3" protected bond.

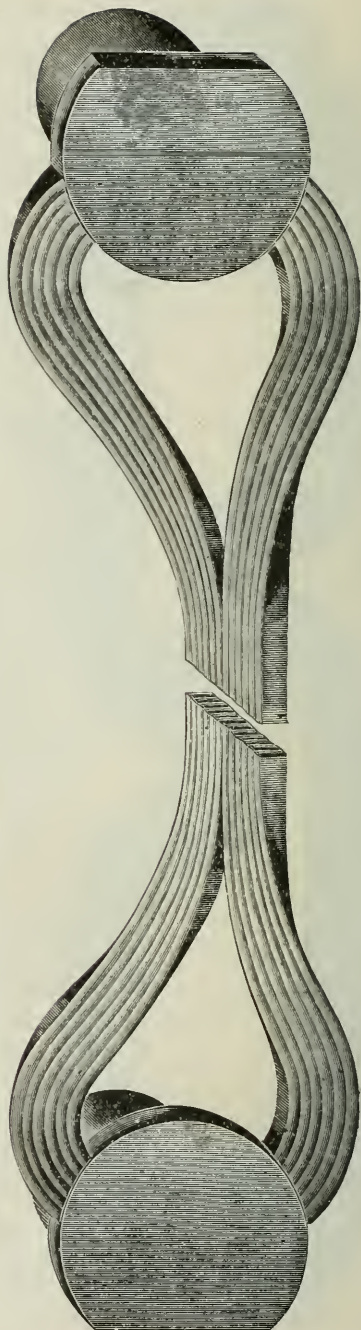


FIG. 8.—Type "P 4" bond.

rod and the apertures near the ends allow for the inner bolts. For this condition of space, tie rods and bolts, it is claimed that no bond of equal cross-section can be constructed, placed under the joint and proven practicable, except on the lines of the above protected bonds.



FIG. 7.—Type "L 1" protected bond.

Type "L 1" protected bond (standard "hydraulic" foot bond), *Fig. 7*, is especially designed to be applied to the foot of either T or girder rails. A tapered hole is punched in the foot of the rail, the large diameter of the hole being at

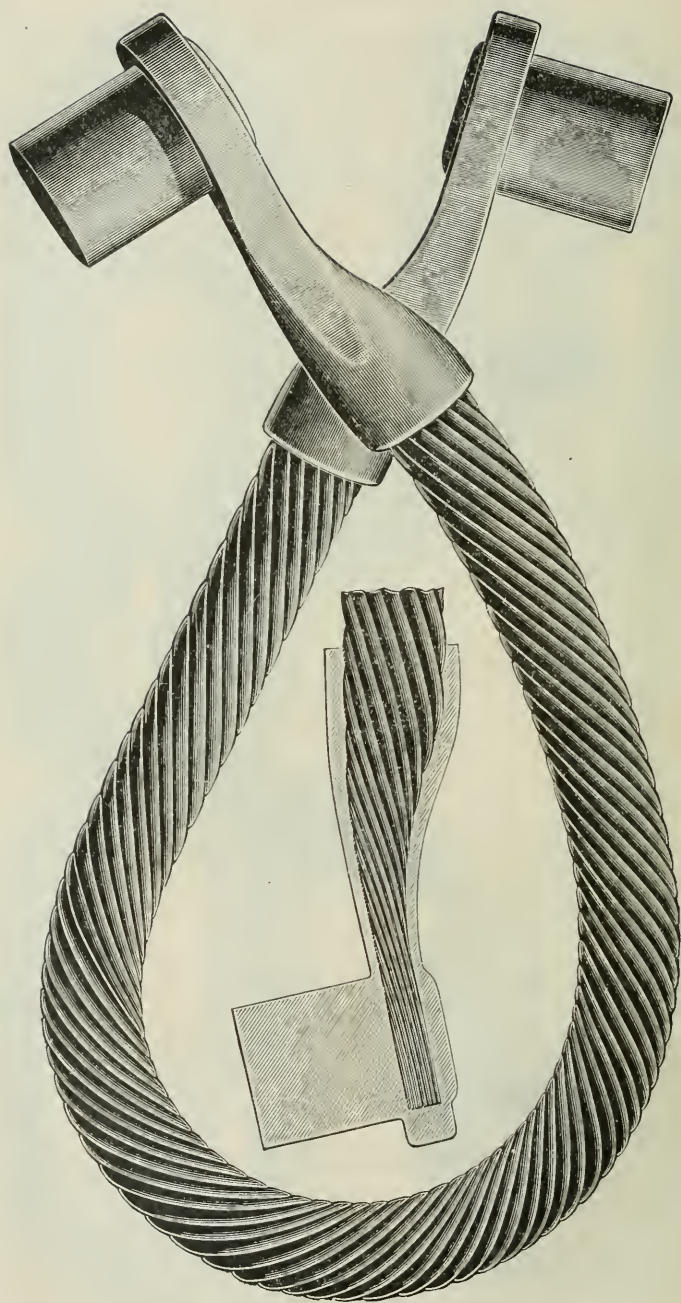


FIG. 9.—Type "P 4" bond.

the top surface. The bond is applied underneath the foot, the hydraulic compressor forcing the terminal back into the tapered hole toward the small aperture until the end of

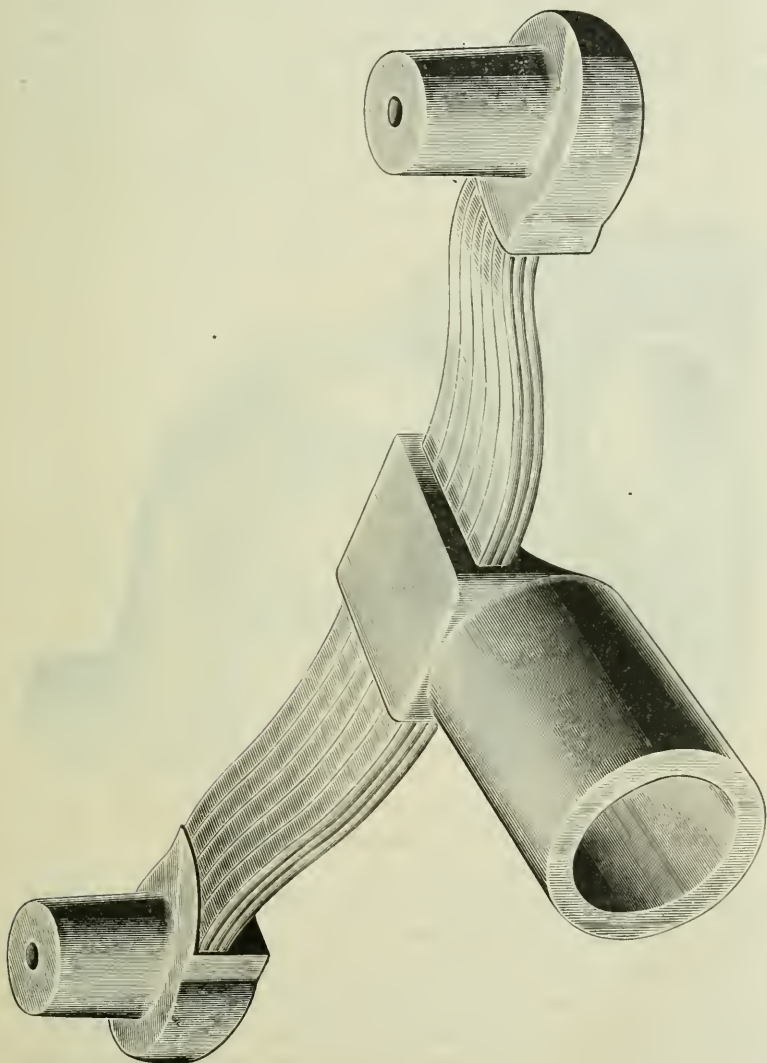


FIG. 10.—Boston special feeder tap.

terminal is flush with the top surface of rail foot. The terminal heads are tapered to compensate for the taper of rail foot and the uniform distribution of metal in the hole.

High speed "third rail" electric roads are using this bond on the contact rail.

Type "N 1" protected bond, *Fig. 8*, is designed for use on elevated railway work where the constant vibration is an important factor to provide against. This bond is composed of flat parallel wires, wound in continuous loop, which loop is spread into a broad opening where it enters and passes through the terminals. This construction produces a "cushion" which overcomes the concentration of the

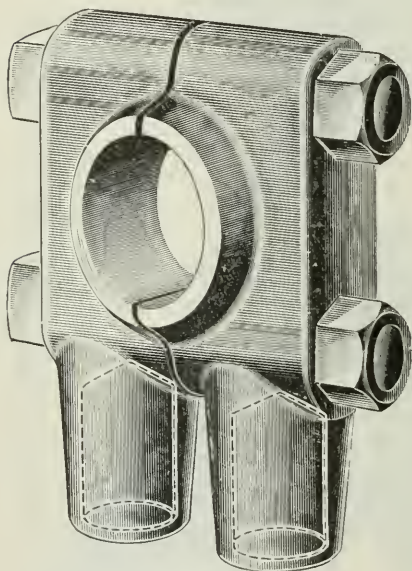


FIG. 11.

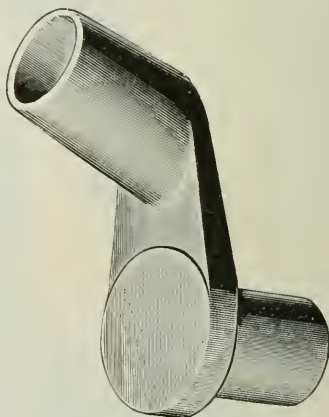


FIG. 12.

Manhattan feeder clamps and terminals.

vibrations in any one spot and thus eliminates crystallization and breaking of the wires.

Type "P 4" bond, *Fig. 9*, is a type of flexible bond, made of copper cable for use in cross bonding, special work, bonding around joint plates, etc. The method of constructing this bond is entirely new and is designed to overcome hammering and injuring the fine wires where they lead out of the terminal heads. The terminals are fused on to the cable in a long cylindrical neck, which is a part of the

terminal head. About one-half of this cylindrical neck, including the head, is then forged as shown by illustration, and the other half is left cylindrical, forming a protecting sleeve around the cable which leads out from the end of this sleeve in its original round form. This bond is used by the Manhattan Elevated Railway, New York, for all the "wheel" rail-bonding, as well as for the structure girders which are utilized for the return circuit.

Boston Special Feeder Tap. The illustration, *Fig. 10*, shows the type of feeder tap or equalizer adopted by the Boston Elevated Railway for connecting the contact rail with the cable feeding it. It consists practically of a type

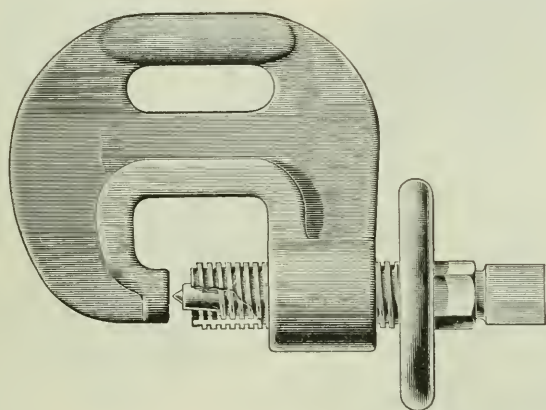


FIG. 13.—Rail-bond compressor.

"L 1" "hydraulic" foot bond of 250,000 C.M. section with $\frac{7}{8}$ -inch terminals on 7-inch centers. Over the middle of the bond strands is fused an arm or extension, having a carrying capacity equal to 500,000 C.M. and over. A hole is bored into this extension which takes in a 500,000 C.M. cable. This connection is then soldered. The terminals of the bond are applied to the base of the contact rail by means of hydraulic foot bonding tools. This tap is also used for connecting the ends of contact rails at highways, where underground cable is used for completing the circuit.

Manhattan Feeder Clamps and Terminals. Illustrations, *Figs. 11—12*, show the types of clamps and terminals used by

the Manhattan Railway of New York for equalizing or tying together the contact rail and the cable feeding it. The terminals have $\frac{1}{8}$ inch studs and are compressed in the web of rail. The sleeve is bored for 250,000 C.M. cable. The clamp is made in two halves and bolted together around the main feeder cable and then soldered thereto. The lower end of each half is bored for 250,000 C.M. cable, and short lengths of this cable connect the clamp and the termi-

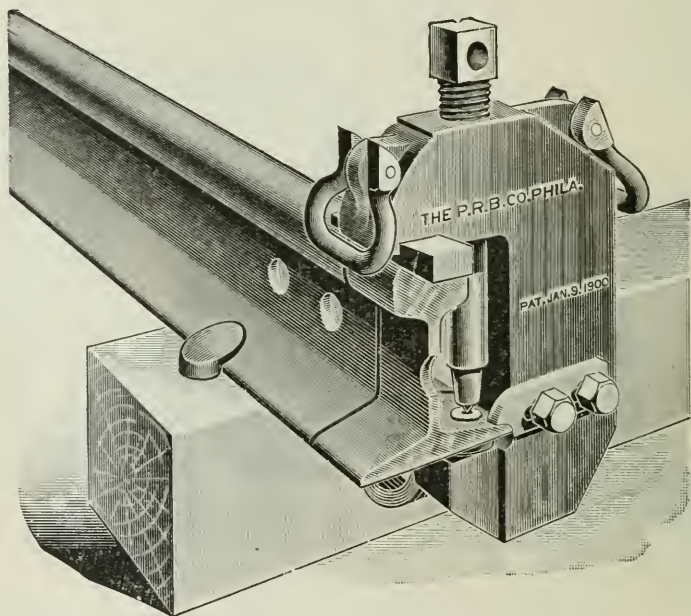


FIG. 14.—Type "4" foot-bond screw compressor.

nals by being soldered into the respective sleeves. The clamp is made to fit around a cable of 1,500,000 C.M.

Improved Rail-Bond Compressor.—After the bond terminals are slipped into the holes and the compressor, *Fig. 13*, placed in position, the outer screw is drawn up with the hand-wheel until it reaches the rail-web, thus holding the tool rigidly and drawing the bond "home." The inner screw is then drawn in with the wrench to compress the terminal, the point on the screw striking the indenture in the termi-

nal as a center guide. The compressing power of these machines is 20 tons.

Type "4" Foot-Bond Screw Compressor. This tool, *Fig. 14*, is designed for use in the application of type "L" protected foot-bonds to the base of rail. It is made with the body or frame of forged steel. The compressing screw is

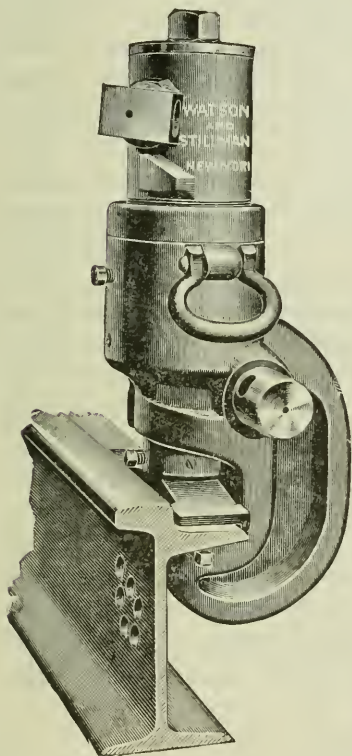


FIG. 15.
Hydraulic tram bond punch.

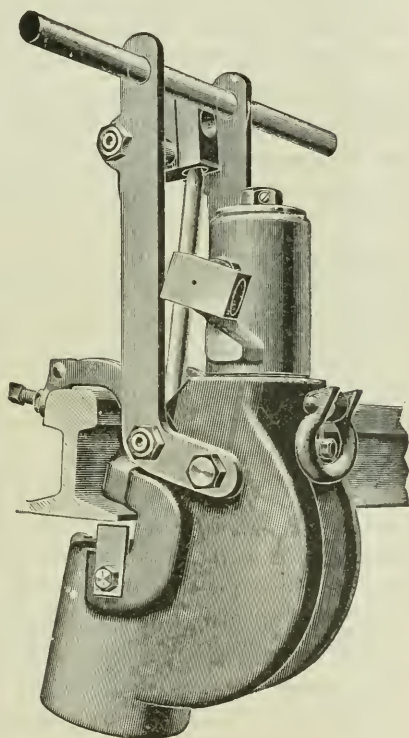


FIG. 16.
Hydraulic foot-bond punch.

made of tool steel with square cut threads and carefully tempered. Handles are provided for the convenient handling of the tool. The tightening wedge is attached to the body with a chain so as not to become lost or mislaid. Weight of tool, 65 pounds.

This type of compressor is for use when the bond holes are drilled at a right angle with the bottom surface of rail-

foot. The bonds in such instances are made with plain flat heads.

Hydraulic Tram Bond Punch. This tool, *Fig. 15*, is designed for punching the bond holes in the tram of girder-rails, principally for re-bonding in paved streets. It is necessary to remove but two belgian blocks, where such are used, to make room for the tool. A tapered hole is punched in the tram, the large aperture being on top, so that when the bond terminal is compressed, it is crowded back against the small aperture of the hole. The die is placed at the ram on top of the tram, and the punch being under the tram it allows the slug to fly upward and out of the tool. The tool is provided with a guide plate to show exact location of bond hole. Weight of complete tool about 140 pounds.

Hydraulic Foot-Bond Punch. This tool, *Fig. 16*, is designed to punch the bond holes in the foot of T-rails. The ram and punch are at the bottom or underneath the rail and operate upwards, punching a tapered hole with the large aperture at the top. The tool is designed to operate at an angle from the bottom of rail and punches the hole at a right angle with top surface of the rail base. Dogs provided with adjusting screws drop over the ball of the rail, preserving the alignment and holding the tool firmly during operation. Guide pieces are provided to show proper location of bond holes. A rod placed at the end of the punch after the slug is removed forces the ram back into the cylinder by a crank placed between the two vertical handles. Weight of complete tool about 180 pounds for-100 ton size and about 150 pounds for the 75-ton size.

(To be continued.)

Notes and Comments.

INTERNATIONAL ELECTRICAL CONGRESS AT ST. LOUIS, SEPTEMBER 12-17, 1904.—PRELIMINARY PROGRAM.

In connection with the Universal Exposition of St. Louis, in 1904, commemorating the Louisiana Purchase by the United States, it is proposed to hold an International Electrical Congress.

The last International Electrical Congress was held in 1900, in conjunction

with the Universal Exposition at Paris. The last preceding International Electrical Congress in the United States was held in 1893, in connection with the World's Fair at Chicago. Electrical Congresses held in the past have had an important influence on the world's progress in the knowledge of electricity and magnetism, and in the application of these sciences. It is confidently expected that the International Exposition of 1904, at St. Louis, may be equally successful in these directions.

The date set for the International Electrical Congress of St. Louis, is the week 12th to 17th September, 1904 (inclusive). This is the week preceding the session of the great Scientific Congress appointed by the Universal Exposition. On this account many of those who attend the International Electrical Congress will probably remain to attend the International Congress of the Arts and Sciences.

In accordance with the present plan, members arriving via New York will be enabled to reach St. Louis via Niagara Falls on Sunday, September 11th. Members will also be invited to attend the dedication ceremonies of the National Bureau of Standards at Washington. It is hoped that arrangements may be completed whereby the President of the United States may then meet the members.

On the morning of September 12th, at 11 A. M., a general convocation of the International Electrical Congress will be called. On the four succeeding days, from the 13th to the 16th inclusive, meetings of the eight sections of the Congress will be held simultaneously. On the final day, September 17th, a second general convocation will be called. Members returning from St. Louis to New York may elect to stop off at Chicago and at Niagara Falls.

As at present proposed, the International Electrical Congress will comprise three distinct features :

(1) A Chamber of Delegates appointed by the various Governments, and essentially similar to the Chambers of Government Delegates at the International Electrical Congresses of Chicago in 1893, and of Paris in 1900. It would seem that sufficient material had been collected since 1900, calling for international action, to warrant inviting the various Governments to appoint delegates, as before, to the International Electrical Congress of St. Louis.

(2) The main body of the Congress, divided into the following sections :

General Theory : Section A, Mathematical, Experimental.

Applications : Section B, General Applications ; Section C, Electrochemistry ; Section D, Electric Power Transmission ; Section E, Electric Light and Distribution ; Section F, Electric Transportation ; Section G, Electric Communication ; Section H, Electrotherapeutics.

It is proposed to invite prominent men in various parts of the world to contribute special papers on subjects represented in the various sections and their subdivisions.

(3) Conventions simultaneously held, in connection with the Congress, by various electrical organizations in the United States. It is proposed that each section of the Congress may be able to hold its meeting under some plan of conjunction with the organization or organizations devoted to the progress of the work selected by that section. Steps have already been taken to enlist the sympathy of the various organizations, with a view to perfecting the details of co-operation at a later date.

The Universal Exposition at St. Louis has signified its intention of affording ample facilities for the accommodation of the Congress in its halls on the grounds of the Exposition.

The Committee of Organization of the Congress is as follows :

President, Elihu Thompson ; Vice-Presidents, B. J. Arnold, Prof. H. S. Carhart, Prof. W. E. Goldsborough, C. F. Scott, Dr. S. W. Stratton ; General Secretary, Dr. A. E. Kennelly ; Treasurer, W. D. Weaver, and an Advisory Committee of twenty-five.

The plans of the Committee of Organization are to invite *all interested* in electricity and its applications to accept membership in, and to attend the Congress if possible ; to convene the Congress during the week set aside by the Universal Exposition for that purpose (12th to 17th September) ; to report the meetings of the Congress ; and to publish the transactions subsequently, each member of the Congress to receive a complete copy thereof.

COLOR-CHANGES BY RADIUM RAYS.

According to Mr. W. Ackroyd, color-changes are frequently brought about by the action of radium rays. These changes have been examined by embedding a radium bromide tube in the substance experimented upon. After a few hours sodium chloride becomes orange or buff colored, potassium chloride becomes violet, but returns to its original color very quickly after removal of the exciting cause. Sodium bicarbonate and potassium metabisulphite are changed to amethyst color after twenty-four hours' exposure.—*London Nature*.

RAMSAY ON RADIUM AND HELIUM.

Sir William Ramsay, professor of chemistry at University College, London, who, with Lord Rayleigh, separated helium from the air, in a lecture before the London Institution, made the interesting announcement that his experiments with radium had shown that that element has the power of changing by some subtle process into another element, namely, helium. He described how a long search into the problem of what becomes of the minute particles with which radium is always parting was quite lately rewarded. Besides its other manifestations, radium constantly gives off an emanation which seems to behave in all respects like a heavy gas. It can be collected in tiny flasks, measured, weighed and used to display the characteristic properties of radium, but it is not permanent. In about a month it entirely disappears. The question is, "What becomes of it?" Sir William has caught this emanation in the act of vanishing. He found that after it had been collected a couple of days its spectrum, which previously was entirely unlike any yet studied, began to display the typical yellow line of helium.

In four or five days the helium grew brighter, and in another week the spectrum of helium was positively blazing in the hermetically sealed tubes that had been filled with the pure emanations or gaseous output of radium. In other words, one element had been literally seen to change into another.

This realization of one of the oldest of human dreams was, said Professor Ramsay, very suggestive of transmutation. The problem might not be actually solved, but it was by no means absurd. Professor Ramsay calculated that if radium turned into helium and nothing else it would take 2,000,000 years

to dissolve into gas; but if helium is only one of the substances given off, transmutation would be proportionally shorter. He is now investigating to learn precisely how much helium was produced from the radium, what happened in the change and how long it took. He pointed out that several groups of elements linked together by Mendeljeff's periodic law showed a remarkable similarity of properties, tending to suggest that the accepted elements were not the final forms of matter, and that they were ultimately reduced into a few simpler forms. He asked if the world was on the verge of some great generalization, showing that all the so-called elements were merely elusive forms of one or two fundamental kinds of matter.

Professor Ramsay stated that Professors Rutherford and Soddy were co-operating with him in his investigations. He incidentally remarked that the price of radium had increased ten-fold in the last six months, owing to the action of the Austrian Government, which had created a corner therein by refusing to allow further exports of refuse from the uranium oxide works at Joachimthal. As a result, the nominal price of radium is about \$250,000 for one-fifteenth of an ounce.

Among a number of other interesting points the lecture showed the power of radium to make certain minerals and chemical compounds luminous. Professor Ramsay subjected a piece of the mineral willemite to the "bombardment" of radium particles, whereupon it shone brightly. In an interview after the lecture, Sir William said it was practically impossible at present to obtain more radium. It had been said that an American company had been formed to mine it, but he had tested the American ores supposed to contain it and found them absolutely worthless.—*Electrical World*.

THE PETROLEUM FIELDS OF CALIFORNIA.

The United States Geological Survey, within the last eighteen months, has been making a preliminary examination of the productive oil fields of California, with a view, first, to acquiring a knowledge of the general conditions of occurrence of petroleum in the State; and, second, to applying the laws that may be deduced from such researches to other portions of the Coast Range. The Director of the Survey has long recognized the paucity of knowledge relating to Coast Range geology, and in view of the fact that several of the formations of this region are oil-bearing he is now directing especial efforts to unraveling the intricate problems with which mining engineers, oil men, and others have to do in the prosecution of their professional and industrial work. A considerable number of topographic maps, covering the agricultural regions of southern California, have already been published—these with special reference to the water supply. Latterly other sheets of a similar nature, but covering more particularly the oil fields, both productive and prospective, have been prepared and are now in the hands of the engraver. Still others are under survey in the field. Eventually it is proposed to cover the entire area of the Coast Range, the field work to be carried on as rapidly as the resources of the Survey will permit.

Recently a member of the Survey has made an extended preliminary examination of the more productive oil fields and the territory adjacent, and it is the intention to make public this information in a report to be issued in the latter part of this year. It is the Director's desire, in the preparation of this

report, that it shall contain such facts as will be of especial service to men interested in the development of oil fields. The subject-matter of the report will therefore embrace such maps of the Survey as are available, others more on the order of land surveys, which will serve a temporary purpose, sections of the formations and structural features encountered, and the text descriptive thereof.

It may be mentioned in passing that the Coast Range of California, from a geological standpoint, is as little known as many of the more inaccessible portions of the United States. Since the surveys of Whitney little attention has been given to this important mountain system, the Sierras, richly productive in gold and silver, having absorbed the principal efforts of the geologists, State as well as Governmental. In the prosecution of the surveys in the coast ranges the work has to be undertaken from the beginning, and many general problems of geology must be worked out before satisfactory conclusions may be drawn with regard to economic problems. As nearly as possible, however, these investigations will go hand-in-hand, for no one more fully recognizes the necessity for studies of the mineral wealth of our country than the Director.

Incidentally attention is called to a recent bulletin, No. 213, of the United States Geological Survey, entitled "Contributions to Economic Geology, 1902," in which a brief account of the oil fields of California is given.

THE GYPSUM DEPOSITS OF LARAMIE PLAINS, WYOMING.

In the course of work for the United States Geological Survey, Dr. W. C. Knight has made a report on the gypsum and plaster industry in Wyoming.

The gypsum deposits of the Laramie Plains are very extensive and varied. They occur in or are associated with the Red Beds, and extend along the foot of the Laramie Mountains from the Colorado line northward for a distance of more than 60 miles. In this distance there are some faults and also some slight folds which prevent the deposits from following the strike of the range.

The deposits belong to two classes, the primary and the secondary gypsum. The primary beds are located about 700 or 800 feet below the top of Red Beds. They vary in thickness from 6 to 50 feet, and usually dip to the west at an angle of less than 10° . The thickest beds are at the south end of the Plains, in the vicinity of Red Mountain. The gypsum, so far as tested, is very pure and makes a first-class plaster of paris, as well as good land plaster, and also the new kind of wall plaster in which a retarder is used and which is fast taking the place of lime in general construction work. The secondary beds are superficial or nearly so, and are composed of gypsum in a finely divided state, mixed with sand and granular carbonate of lime. These deposits occur in undrained depressions below the Red Beds, and out-crop occasionally along the entire length of the Red Beds. These secondary accumulations often cover many acres in extent, and are of exceptional value on account of the cheapness of quarrying, the dust-like condition of the product, and its superior quality. Beds of this kind are plowed, and the gypsum is carried in wheeled scrapers to the mill, where, without passing through the usual grinding machinery, it is simply put through the regulation boiler for plaster of paris, and the product is finished.

The development of the gypsum industry has been very backward until recent years. The Red Buttes Plaster Company erected a plant at Red Buttes for the manufacture of plaster of paris about 15 years ago. On account of high freight rates and Colorado and Utah competition this plant has never worked continuously. This company quarries from 6 to 10 feet of first-class gypsum and manufactures plaster of paris and the new wall plaster in which the retarder is used. The company turns out annually from 600 to 800 tons of the various products. The development of the secondary beds is much more recent. Several years ago a large plant was erected at Laramie, and was conducted with indifferent success until it passed into the hands of the Acme Company. Since then it has been operated at full capacity, and has been marketing about 100 tons of plaster per day. The Acme Company is working a bed 9 feet deep that is located at the plant. About a foot of soil has to be removed from the surface of the deposit, and the rest of it is of the same color and grade to the bottom. This is manufactured into various kinds of plaster, but the leading brand is the "Laramie Standard Plaster," largely utilized for plastering the interior of houses. It makes a stronger plaster than lime; it is harder and stands better than any other finish for a wall.

CEMENT FROM SLAG.

In a recent United States consular report it is stated that the manufacture of cement from blast-furnace slag and limestone in Germany and Belgium has proved successful, and that negotiations are now being carried on to establish the industry in England. It is claimed that Portland cement can be manufactured more cheaply from slag and limestone than from the materials at present employed; and that, owing to the uniformity in the composition of the slag, the finished product is less liable to variations in composition, and is therefore more trustworthy. Mortar made with slag cement in the proportion of 3 parts sand with 1 part cement had a tensile strength of 383 pounds per square inch after seven days' hardening, and a strength of compression of 3,880 pounds per square inch. After twenty-eight days the strengths had increased to 551 pounds and 5,441 pounds respectively.

It will be recalled by some of our readers that the late Frederick Ransome, of London, England, was engaged for many years in the manufacture of a hydraulic cement from blast-furnace slag by a patented process, though with what success we are unable to state. The comment is made merely to indicate that the proposition to utilize this waste product for the purpose is not a new one.

SYNTHETIC ALCOHOL.

Some very curious, semi-industrial experiments were recently made at Puteaux in the experimental laboratory of the Compagnie Urbaine d'Eclairage par le Gaz Acetylene, in the presence of its stockholders and a few favored persons, and the object of which was to demonstrate the possibility of manufacturing alcohol by starting with the elements carbon, hydrogen and oxygen.

The problem seems to us to have been admirably solved, although there were presented to us only the problems of Berthelot, the inventor and father

of organic synthesis, the modern improvers of whose theory, however, have profited by all the discoveries of science since 1855, and particularly those of the electric furnace, electrolysis, etc.

A new carbide (?), which is presented to us as *ethylogen*, undeniably possesses the property of disengaging ethylene gas, that is to say, the synthetic nucleus of alcohol, instead of acetylene gas, when it is plunged into water. Since this carbide is decomposed by water, at the works of production itself, in gasometers identical with those employed for the production of acetylene, there is nothing to prevent the residuum from being used anew, with the addition of carbon naturally, for indefinitely reproducing the same ethylogen carbide. This, in fact, is what occurs, save some insignificant losses of metallic substances, the final expense of the operation being summed up in the addition of carbon (represented here by coke-breeze), and much electric energy, which may be furnished by waterfalls.

The ethylene gas disengaged is received in a gasometer, whence it is pumped and made to bubble through sulphuric acid contained in a series of leaden vessels. The acid absorbs the ethylene gas in producing ethyl sulphuric ether, which thus becomes the raw material from which may be obtained a host of organic products. Upon distilling it with much water, in fact, we obtain alcohol; upon distilling it with less water, we directly obtain ether; and, in causing air, or, more accurately, its oxygen, to intervene, we obtain acetic acid, acetone, and even other carburets.

In the case of alcohol and ether, the true crude materials are the coke of the carbide and the water added to the sulphuric acid, since the metallic salts and the acid (after concentration) may, so to speak, be used indefinitely. In the case of acetic acid and acetone, the air furnishes its complement of oxygen. There remains, therefore, the carbon, say in practice 440 pounds of coke-breeze, and here is the important point—electric energy obtained cheaply.

For the sake of completeness, let us add that by similar processes, now nearly perfected, it is possible to fix the nitrogen of the air in order to make of it a fertilizer richer and cheaper than the nitrates of Chili. This information may interest our numerous readers who are occupied with agriculture.

All this together constitutes the entrance of chemical synthesis into the domain of industrial practice. It is a complete evolution of chemical industry.—*Scientific American Supplement*.

LINED TUBING *vs.* SOLID METAL.

The Metal Industry says: The use of brass in furniture trimmings and similar goods is a matter which usually does not require the highest grade of material. Finish is generally paramount to everything else. Our attention was recently called to the extending use of lined tubing in this and similar trades, and we were more or less surprised to find the quality of the tubing as good as it is and admirably adapted to the uses to which it is put.

The advent of the brass bedstead in the United States is apparently responsible for the production of lined tubing, for here was a case where nothing was required except finish and the requisite strength. The early bedstead manufacturers made tubing themselves by forming brass sheet over iron pipe. This gave the requisite strength. The call for better material, however,

became loud, and the maker soon found that to produce a good material it is necessary to use a lining metal which has a smooth, cylindrical surface. Seamless drawn steel tubing is now used, and over it the brass tube is drawn so that, to all appearances, a solid brass tube is produced. We have recently seen such tubing stand all the difficult bending that could be given a seamless copper tube, and, for many purposes, such as bedsteads and show work of various kinds, it possesses every advantage of the seamless or brazed product. This tubing should supplant the electro-plated iron rod upon which a thin coating of brass has been put, as such material sooner or later rusts and becomes unsightly. Several of the brass manufacturers have begun the manufacture of a good lined tubing, and we believe that many new uses will be found for the product.

Franklin Institute.

[*Proceedings of the stated meeting held Wednesday, December 16, 1903.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, December 16, 1903.

President JOHN BIRKINBINE in the chair.

Present, 54 members and visitors.

Additions to membership since last report, 13.

The following nominations were made for Officers, Managers and Members of the Committee on Science and the Arts, to be voted for at the annual election, January 20, 1904, viz.:

<i>For President</i>	(to serve one year)	JOHN BIRKINBINE.
" <i>Vice-President</i>	(" three years)	HENRY HOWSON.
" <i>Secretary</i>	(" one year)	WM. H. WAHL.
" <i>Treasurer</i>	(" ")	SAMUEL SARTAIN.
" <i>Auditor</i>	(" three years)	JOHN GEO. COPE.

For Managers (to serve three years).

ROBERT C. H. BROCK,	HENRY R. HEYL,
STEPHEN GREENE,	ALEX. KRUMBHAAR,
ALFRED C. HARRISON,	C. HARTMAN KUHN,
CHAS. A. HEXAMER,	WALTER WOOD.

For the Committee on Science and the Arts (to serve three years).

L. L. CHENEY,	JOHN HAUG,	L. F. RONDINELLA,
JAMES CHRISTIE,	FRANCIS HEAD,	ARTHUR J. ROWLAND,
G. H. CLAMER,	CHAS. A. HEXAMER,	SAMUEL SARTAIN,
J. LOGAN FITTS,	WALDEMAR LEE,	FRANK SHUMAN,
RICHARD W. GILPIN,	JACOB Y. MCCONNELL,	F. CARPENTER SMITH,
WM. O. GRIGGS,	J. W. RIDPATH,	THOMAS SPENCER,
J. C. TRAUTWINE, JR.,	URBANE C. WANNER.	

(To serve for two years.)

J. M. EMANUEL.

(To serve for one year.)

AMOS P. BROWN,
WM. W. CANBY,DANIEL EPPELSHEIMER, JR.,
JAMES S. ROGERS,

GEORGE P. SCHOLL.

The paper of the evening was read by Mr. John M. Hartman, on "The Regulation of the Smoke Nuisance in Philadelphia."

The speaker made some brief introductory remarks on the general subject of fuels, furnaces and proper and improper methods of firing; gave some account of what has been accomplished in other places to regulate the burning of soft coal; and proceeded to narrate his experience as Chairman of a Committee of City Councils in endeavoring to frame, and secure the passage of, a satisfactory smoke-prevention ordinance.

The subject was very freely discussed by Messrs. Jacob Reese, Wm. L. DuBois, Henry G. Morris, James Christie, A. E. Outerbridge, Jr., Henry F. Colvin, and others.

The thanks of the meeting were voted to Mr. Hartman for his able presentation of the subject.

The President announced the appointments of seven members to serve as tellers of the annual election, and the meeting was adjourned.

WM. H. WAHL,

Secretary.

Committee on Science and the Arts.

(Abstract of the stated meeting held Wednesday, December 2d, and of the adjourned meeting of December 9, 1903.)

MR. CHAS. E. RONALDSON in the Chair.

(No. 2258.) *Convertible and Semi-Convertible Cars.* J. G. Brill Co., Philadelphia.

ABSTRACT: These inventions are covered by letters-patent to J. A. Brill (No. 623,724 and No. 691,351).

The "Convertible" car belongs to that type of car which is open at the sides to admit passengers when the cars are in use as summer cars, and having means for closing them to protect the passengers from inclement weather. In thus closing them, they are transformed into a center-aisle car, to which access is obtained from the end platforms only.

To effect this transformation the convertible cars are provided with means for closing the sides with substantial panels from the floor upwards, where they are met by glazed sash, which are drawn down from above, the panels, sash and curtains being stored in suitable pockets provided for the purpose in the roof, so that, at any time, with very little trouble they may be transformed from open cars having side entrances into closed cars having only end entrances.

In the semi-convertible type the side foot-board is omitted, there being only end entrances with cross seats and a center aisle. The panels are permanent, and the sashes, which are made unusually wide and deep, are not

removed from the cars, but may be raised and lowered at will. The permanent panels thus keep the lower part of the car always closed. When the sashes are raised the cars are practically wide open; when they are drawn down they are securely closed against wind and rain.

The report approves and commends the devices above described as ingenious and practical. The award of the John Scott Legacy Medal and Premium is recommended to be made to John A. Brill, the inventor. (*Sub-Committee*, Henry R. Heyl, Chairman; Henry F. Colvin.)

The following reports passed first reading:

(No. 2279.) *The Electric "Buzz" Fan*. Dr. S. S. Wheeler's claims to the invention of.

(No. 2295.) *Switch-Operating Device*. George B. Conrey, Philadelphia.

(No. 2304.) *The Molecular Structure of Cast Iron*. A. E. Outerbridge, Jr., Philadelphia.

(No. 2306.) *Nut-Lock*. James Walsh, Jr., of Philadelphia.

Report No. 2164 (Parker's Steam Generator) was discussed and held under advisement.

Application No. 2284 (D'Auria's proposition) was dismissed without prejudice. W.

Sections.

[Abstracts of stated meetings.]

ELECTRICAL SECTION.—*Stated Meeting*, held Thursday, November 12, 1903, 8 P.M. Thomas Spencer, President, in the chair. Present, 30 members and visitors.

Dr. Joseph W. Richards, of Lehigh University, Bethlehem, read the paper of the evening, on "The Electrolysis of Water," discussing the subject from the theoretical viewpoint.

The paper was discussed by Messrs. Carl Hering, C. J. Reed, Thos. Spencer and the author.

Mr. H. C. Snook, manager of the Röntgen Manufacturing Company, of Philadelphia, described and exhibited a new form of mechanical interrupter for the induction coil.

Stated Meeting, held Thursday, December 10, 8 P.M. Mr. Spencer in the chair. Present, 18 members and visitors.

Dr. Richards concluded his paper on "The Electrolysis of Water." In this installment the author described a number of forms of apparatus devised for various commercial applications of water electrolysis, illustrating the subject with the aid of lantern photographs. The paper was fully discussed.

Dr. Geo. P. Scholl presented a résumé of recent progress in the Electro-Metallurgy of Iron and Steel.

RICHARD P. BINDER,
Secretary.

MECHANICAL AND ENGINEERING SECTION.—*Stated meeting*, held Thursday, November 19th, 8 P.M. Mr. Henry R. Heyl in the chair. Present, 42 members and visitors

Mr. J. B. Semple, of Pittsburgh, Pa., presented a paper describing an improved projectile of his invention, which he calls the "Torch-Shell. This projectile is provided with means for automatically illuminating its path at night, thus rendering it possible to attain greater accuracy of firing, and incidentally offering numerous other advantages, which the inventor dwelt upon. The subject was illustrated with the aid of specimens, drawings and lantern photographs. It was voted to refer the subject to the Committee on Science and the Arts.

Mr. Kern Dodge followed with a paper dwelling principally on the application of the electric motor for driving machinery, and emphasized the remarkable changes which the introduction of electricity had brought about in the modern machine shop. The paper was fully illustrated with the aid of lantern projections.

D. EPPELSHEIMER, JR., *Secretary.*

SECTION OF PHOTOGRAPHY AND MICROSCOPY.—*Twenty-fifth Stated Meeting*, held Thursday, December 3, 1903. Mr. J. W. Ridpath in the chair. Present, 45 members and visitors.

The paper of the evening was presented by Prof. Richard Zeckwer, on "Photography as an Aid to Music." The speaker illustrated his subject by a number of experiments with sensitive flames, showing the presence of sympathetic vibrations, etc. He also exhibited a number of lantern photographs made by himself, of human subjects, which demonstrated the differences of touch on the piano in playing *legato*, *staccato*, etc.; peculiarities exhibited by singers in chest and diaphragm breathing; and photographs of sound waves, exhibiting the phenomena of reflection, refraction, interference, etc.

The paper was freely discussed by Messrs. E. Goldsmith, L. E. Levy and the author. The Chairman expressed the appreciation of the meeting to the speaker for his admirable communication. Adjourned.

M. I. WILBERT,
Secretary.

PHYSICAL SECTION.—*Stated Meeting*, held Thursday, December 17, 8 P.M. Prof. Geo. A. Hoadley in the chair. Present, 24 members and visitors.

The first communication of the evening was presented by Prof. Chas. P. Matthews, Purdue University, Lafayette, Ind., on "Modern Methods in Photometry." The speaker, after giving a brief historical sketch of the subject, described the usual methods at present in vogue in lamp factories and research laboratories, and concluded by describing an improved integrating photometer, which he had devised and introduced into service.

The speaker illustrated his address with the aid of a number of lantern photographs. The paper was discussed by Mr. Carl Hering, Mr. Barrett, the Chairman and the speaker.

Professor Hoadley followed with a brief communication, illustrated by lantern views, on "Osmotic Pressure," in which he reviewed the historical development of the subject, dwelling especially on the important results obtained by recent investigations. Discussed by Mr. Hering and the speaker.

The thanks of the meeting were voted to the speakers of the evening. Adjourned.

WM. H. WAHL,
Secretary pro tem.





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Antarctica Addenda.*

BY EDWIN SWIFT BALCH.

Since publishing "Antarctica: a History of Antarctic Discovery" in the *Journal of the Franklin Institute*, 1901, and *Antarctica*, 1902, I have been able to collect a certain amount of new information about the Antarctic, some of which throws fresh light on some points of its geography. And doubtless a great deal more information still remains hidden.

In several places of New England, there are now living merchant captains who have gone sealing in the Antarctic, or whaling in the Arctic, and from three of them, Captains Eldred, Fuller, and Lynch, I have obtained brief verbal accounts of their experiences.

Captain Andrew Eldred, of Stonington, Conn., made four sealing voyages to West Antarctica, in 1874, 1875-76, 1878, 1879-80. In 1875-76, he landed on Palmer Land, somewhere

* Copyright, 1903, by Edwin Swift Balch.

near the entrance of Gerlache Strait. He went mainly to the South Shetlands, however. On Low Island he once found penguins in such numbers that, to enable a landing party to move about, it was necessary for one man to walk ahead and sweep the birds aside with a five-foot club, for they would not move, but remained seated and struck with their sharp-pointed bills at the men. Captain Eldred saw no seaweed, kelp or vegetation whatever at the Shetlands. He never wore furs nor found them necessary during the antarctic summer. On one of his cruises, scurvy broke out on his ship, and canned tomatoes proved an excellent remedy, so much so that Captain Eldred considers them an almost infallible preventive of the disease. Captain Eldred also informs me that the following merchant captains have been sealing to the Antarctic or whaling to the Arctic: Captains C. E. P. Noyes, Samuel Clark, Charles E. Staplin, Billings Burch, Elias L. Maynard and Courtland Wheeler, of Stonington, Conn.; Captains John, James, Albert and Robert Glass, of New London, Conn.; Captains James Buddington and his son James, of Groton, Conn.; Captains Charles Rogers and Benjamin Rogers, of Montville, Conn.; Captain William Rainard, of New Bedford, Mass.; Captain William H. Appleman, of Mystic, Conn.; Captain Walter Chesebro, of Noauk, Conn.; and also a number of others.

Captain Joseph J. Fuller, of New London, now lighthouse keeper at Stonington, served in the United States navy during the Civil War, and afterwards went repeatedly sealing and sea elephant hunting in the Antarctic. He caught many fur seals at the Shetlands, and he thinks the Shetland seals have the best fur of any. He has sailed along the coast of Palmer Land, but has not landed on it. He has been several times to Sandwich Land, but never reached the southernmost island on account of the ice. He has seen bad ice as far north as 54° south latitude. In 1893, in the "Francis Allen," he saw Bouvet Island, which he also calls Circumcision. It is high and rugged in the north, high and covered with snow in the middle, and it slopes down to the sea in the southwest. Captain Fuller's observations place it in $52^{\circ} 55'$ south latitude, $4^{\circ} 10'$ east longitude. He saw Thomp-

son Island bearing about northeast from Bouvet Island, but he could not land on either, on account of ice, wind and fog. Captain Fuller has been at Heard Island, and several times at Kerguelen Island, where he caught many sea elephants, and where he met Captain Nares in the "Challenger." At both these islands he has often seen large icebergs aground. Some of Captain Fuller's experiences corroborate some of the statements of Captain Benjamin Morrell, especially those about the weather, which, in the southern summer, Captain Fuller thinks, is much like the weather at Stonington in March. He has seen the thermometer go from 27° C. to freezing point in a day, but never wore furs, nor thought them necessary during the antarctic summer. Captain Fuller states that Captain John Williams (now deceased), master of the schooner "Golden West," of New London, landed on Bouvet Island about 1878. He could not find anchorage, and it was necessary to go ashore in boats; there were no sand beaches, only rocky beaches, on which five hundred fur seal were taken. Captain Rastus Church, of New London, in the "Delia Church," in 1882 also sighted Bouvet Island, but did not land.

Captains Eldred and Fuller told me that after 1845 there was practically a cessation of sealing round the South Shetlands, because the seals had been nearly exterminated. When the seals were left alone, they increased again, and about 1870 the sealing industry revived somewhat. Since about 1890, however, sealing has been given up, because the Chilian government has stopped sealing round Cape Hoorn, and the six weeks' summer sealing on the Shetlands does not pay enough when the sealer cannot also do some sealing round Tierra del Fuego.

Captain Thomas B. Lynch, now of Peáce Dale, Rhode Island, sailed in 1879 from Stonington in the schooner "Express." In January, 1880, he was for some time in company with Captain Andrew Eldred on the schooner "Thomas Hunt," at the South Shetlands. They landed on several of them and caught thirty-six fur seal. One of these, on Bridgman Island, had the fur all burnt off on one side; they thought that, as Bridgman Island was then smoking, per-

haps this seal had come in contact with some hot lava or volcanic fires. The "Express" and "Thomas Hunt" were looking for the "Charles Shearer," Captain James Appleman, of Mystic, Connecticut, which sailed the year before from Stonington for the Shetlands, but was never heard of again. Captain Lynch, in his search, went to the Powell Islands, to the east coast of West Antarctica as far as Seymour Island, into the north entrance of Gerlache Strait, which was blocked with ice, and down the west coast of West Antarctica to 66° south latitude. He still has the log of his cruise and a British Admiralty chart which he used and on which he marked his positions. Captain Lynch told me that in 1876 Captain James Buddington, of Groton, in the "Florence" and Captain Glass in the "Francis Allen" sailed from New London for the Shetlands. The mate of the "Florence," King, of Yonkers, New York, landed with a crew on Ragged Island. Owing to the sudden drifting in of the ice, neither ship was able to pick them up. King and his men spent the winter at Potter Cove, under the shelter of their boat. The crew all died, but King was rescued at Potter Cove in 1877 by Captain Glass in the "Francis Allen." Captain Lynch saw the remains of the boat and shelter in 1880. Potter Cove is on the southwest shore of King George Island. It is about a kilometer and a half long and half a kilometer wide and it is surrounded by high mountains and glaciers. From the latter, bergs break off every few hours and, with a report like heavy cannon, fall into the water with a crash that will make a vessel tremble. Near the beach in Potter Cove there is a peak, twenty-five to thirty meters high, which the sealers call the Crown. This is the only land in the Shetlands which Captain Lynch saw entirely free from ice and snow. He found the dirt on it decidedly warm. He saw thousands of stormy petrels, or Mother Carey's chickens, which he has never seen on land anywhere else, flying about there, and discovered that they buried their eggs just below the surface of the dirt to be hatched by the heat.

Mrs. Richard Fanning Loper, of Stonington, daughter of Captain Alexander S. Palmer, has given me much informa-

tion about her uncle, Captain Nathaniel Brown Palmer, the discoverer of Palmer Land. There is a short account of his life in *The Sun*, New York, Sunday, July 8, 1877, page 3, and another in *History of New London County, Connecticut*, edited by D. Hamilton Hurd, Philadelphia, J. Lewis & Co., 1882, pages 708-712. Mrs. Loper owns several of his log books, and a number of letters and memoranda relating to him, and I am indebted to her for much information about her uncle.

Captain Nathaniel Brown Palmer was born at Stonington, Conn., August 8, 1799. He went to sea, first in the coasting trade, in 1813. In 1818, he became "second mate of the brig 'Hersilia,' bound to Cape Horn for seals, Captain James P. Sheffield, master. On this voyage he and a sailor were left upon one of the Falkland Islands to obtain provisions for the brig, while the 'Hersilia' went in search of the fabulous Auroras. Soon after the departure of the brig, the 'Esprito Santo,' from Buenos Ayres, hove in sight off the island, and 'young Nat,' as he was then called, piloted her into the harbor, and found that she was bound to a place where there were thousands of seals, but [her captain] refused to divulge the situation. Three days later, the 'Hersilia' returned, and 'young Nat' told Captain Sheffield about the 'Esprito Santo,' and said he could follow her and find the sealing ground. Captain Sheffield, having great confidence in his second mate, followed his advice, and in a few days discovered the South Shetlands, at that time unknown in the continent of North America. The 'Esprito Santo' was anchored there, and the crew was much surprised to see the brig, but their admiration for 'young Nat's' skill was so great that they even assisted in loading the 'Hersilia,' and returned home with 10,000 of the finest skins." In 1820-1821 Captain Palmer was captain of the sloop "Hero," and discovered and first sailed along the north coast of West Antarctica. He was an unusually keen-sighted man, and Mrs. Loper has heard her uncle tell how he sighted Palmer Land from Deception Island. Mrs. Loper owns the log of this cruise: only remarks about the weather and the sea are entered during the time in which this exploration was made;

a number of pages, however, are torn out at the end of the log, and it is known that on these was written a full account of the discovery. On this trip, while among some islands, he saw a whale pass between two of them; without a chart, surrounded by breakers and rocks, and with a fierce tide rushing by, he apprehended, with the inspiration of an explorer, that, if a whale could pass, there must be a channel of sufficient depth to float a vessel, and he boldly sailed in the wake of the whale. "In 1821, Captain Palmer was captain of the 'James Munroe,' and joined Captain George Powell, of the 'Dove,' and together they discovered the islands called 'Powell Islands,' Captain Powell saying to Captain Palmer, 'You have given a land your name, let this land bear mine.'" In 1824, Captain Palmer had command of the schooner "Cadet," and sailed for the Spanish Main, where he was employed by the Columbian government to transport a part of Bolivar's army from Carthagena to the river Chagres, and on the return trip a number of Spanish prisoners to Santiago de Cuba. He married Miss Eliza T. Babcock, December 7, 1826. In 1829, he commanded the brig "Annawan" on a sealing voyage to the Shetlands, of which Mrs. Loper owns the log. On this occasion, he sailed westward to try to find the island which was discovered by Captain Swain, and which was sighted also by Captain Macy. He could not find it in longitudes 90° to 100° west, so that it seems almost certain that it is the island afterwards called Dougherty Island (see *Journal of the Franklin Institute*, April, 1901, page 252; *Antarctica*, pages 75 and 185). He afterwards made another voyage on the "Annawan," landed for provisions on Juan Fernandez Island, then a Chilian penal colony, and found the convicts in revolt; they seized the "Annawan" and made Palmer land them on the mainland of South America. His life was spared because he was a freemason; and he kept Mrs. Palmer, who was with him, concealed in the vessel's hold for ten days. From 1833 to 1840, Captain Palmer commanded various packet ships of the Collins Line, among them the "Huntsville," the "Hibernia," the "Garrick" and the "Siddons." In 1841, he sailed the "Paul Jones" to China. Subsequently he superintended

the construction of several clipper ships, and he sailed several of them, the "Honqua," the "Sam Russell" and the "Oriental," to China. He retired from active service in 1848. He had great constructive ability, and supervised the building of a number of yachts and steamers. He was one of the founders of the New York Yacht Club. He corrected the United States Coast Survey Charts of Stonington Harbor, and during the Civil War aided the Government in regard to the transport service. One of his nephews falling ill, he took him for his health, in 1877, to China on a sailing voyage. On the return voyage, his nephew died at sea, and, shortly after reaching land, Captain Palmer himself died at San Francisco, on June 21, 1877.

Mrs. Loper owns, also, a number of memoranda, connected with various persons, relating to the Antarctic. One is a letter of Mr. J. N. Reynolds, in which he criticises severely Morrell, whom he thought too imaginative. Another document shows that it was not Captain Nathaniel B. Palmer, but his brother, Captain Alexander S. Palmer, Mrs. Loper's father, who guided the "Chanticleer" into North Port Hatchet. (See *Journal of the Franklin Institute*, April, 1901, page 260; *Antarctica*, page 93.) This paper reads as follows: "These are to certify the principal officers and commissioners of His Majesty's Navy that Mr. Alexander S. Palmer, Master of the American sealing schooner, the 'Penguin,' piloted His Majesty's sloop under my command, from her anchorage off Deadman's Island (Staten Island) the 26th of October, 1828, to the Harbor of North Port Hatchet (Staten Island), where he this day left her moored in perfect safety. Given under my hand on board His Majesty's sloop 'Chanticleer,' at North Port Hatchet, Staten Island, the 28th day of October, 1828. Henry Foster, Commander."

Dr. J. H. Weeks, Jr., of Stonington, is making an extended study of the voyages of the Stonington whalers and sealers, and I am indebted to him for some valuable data. He is the owner of a large map, which clears up one point in antarctic history. This is "A Chart of the World on Mercator's projection, by John Purdy, published

August 14, 1828, by Richard Holmes Laurie, 53 Fleet Street, London." Dr. Weeks bought this map at a sale held after the decease of one of the Stanton family, but how it came to belong to this family no one knows. Some of the older inhabitants of Stonington think it belonged probably either to Captain Benjamin F. Pendleton, the discoverer of Graham Land, or to Captain N. B. Palmer. This chart shows the north shore of West Antarctica, but not the east coast. The name Trinity Land does not appear, but there is a great bay to the west called Hughes Bay, at the bottom of which is marked "Palmer's Land." This map, it would seem, must be the one referred to by D'Urville as "Laurie's Chart." (See *Antarctica*, pages 81, 82, note 143.) It evidently misled D'Urville into thinking that the north shore of West Antarctica was unnamed, and it was the origin of his error in changing the name of Palmer Land into Louis Philippe Land. There does not seem to be any clue as to where Mr. Purdy got his information, but his map is much less accurate than Powell's Chart of 1822; nevertheless, it was copied rather slavishly by D'Urville. This chart, therefore, seems to furnish definite evidence that *the name Louis Philippe Land should either be eliminated altogether or at least be restricted to the northeastern coast of West Antarctica*. And as the north shore of West Antarctica was discovered by Palmer, and first called "Palmer's Land" after him, it seems the barest justice to demand that *the name Palmer Land should be applied in future to the entire north shore of West Antarctica*

ARTIFICIAL DIAMONDS.

In the November issue of the *Moniteur Scientifique* M. Combes discusses the various attempts which have been made to obtain the diamond artificially. Against the common supposition that the diamond can only be produced at high temperatures, the author cites several observations which seem to indicate that natural diamonds, at any rate, cannot have been formed under such conditions. The hypothesis that high pressures are necessary for the artificial production of diamonds is not in accord with actual experimental facts, and the author arrives at the conclusion that in the experiments of Moissan the pressure plays no essential part, and that the op'ical properties and the analysis of the crystals obtained by this chemist do not warrant the conclusion that these are to be regarded as diamonds.—*London Nature*.

THE FRANKLIN INSTITUTE.

Stated Meeting, held Wednesday, October 21, 1903.

The Belmont Filtration Works.

BY JOHN W. HILL.

Chief Engineer Bureau of Filtration, Department of Public Works,
Philadelphia.

(Continued from p. 31.)

WATER COLLECTORS AND FILTERING MATERIALS.

(Contract No. 49.)

In the center of each filter, at the bottom, as shown in *Fig. 16*, is placed a main water collector into which, at intervals of about fifteen feet, are connected the lateral collectors, to conduct the filtered water from the respective bays to the main collectors.

The main collectors in filters Nos. 1 and 2 consist of a line of 30-inch diameter vitrified sewer pipe, provided at the center of each filter bay with a double 8-inch branch, into which the laterals are connected. The main collectors in all other filters at Belmont were formed by placing concrete-steel reinforced slabs, 5 inches thick, over two low concrete walls built in the center of the filter floor. The walls are 16 inches high, and average $13\frac{1}{2}$ inches thick, plumb on the inside and battered 3 inches on the outside, spaced 4 feet apart; the space between the walls and under the slabs constitutes the filtered water channel. These collectors were built in the filters after all other work, previous to placing the filtering materials, was done.

The lateral collectors, as shown by *Fig. 17*, consist of a line of 8-inch diameter vitrified pipe, perforated all around from end to end, and plugged at the end of the line remote from the main collector.

Around the collectors and for a height of 6 inches from the floor, is placed gravel, ranging in size from 3 inches to $1\frac{3}{4}$ inches in diameter.



FIG. 16.—Section through filters and filtering materials.

Above this is placed a 4-inch layer of gravel, ranging in size from $1\frac{3}{4}$ inches to $\frac{5}{8}$ inch in diameter.

Above this is placed a 3-inch layer of gravel, ranging in size from $\frac{5}{8}$ inch to $\frac{1}{4}$ inch in diameter.

Above this is placed a 2-inch layer of gravel, ranging in size from $\frac{1}{4}$ -inch diameter to material which would be retained on a sieve having fourteen meshes to the linear inch, and above this a final layer, one inch thick, of coarse sand, which would pass a No. 14 sieve and be retained on a No. 20 sieve.

The whole depth of underdrain gravel is therefore 16 inches, measured from the center of the floor inverts.

Three plans have been tested for the distribution of the underdrain materials, as follows:

Plan "A," *Figs. 16 and 18*, shows the gravel everywhere kept from 20 to 24 inches clear of the masonry side and end walls, and piers of the filters.

Plan "B," *Fig. 16*, in which the gravel is kept 24 inches clear of the side and end walls, but impinges against the piers.

Plan "C," *Fig. 16*, in which the gravel is spread horizontally from wall to wall, and impinges against the piers.

Plan "A" requires the least amount of gravel, but is most expensive for labor of placing, while plan "C" requires the largest amount of gravel, but is least expensive for labor of placing.

So far as our experience has gone in the operation of the filters at Roxborough, neither plan has any preference over the other, although plan "A" appears to be the ideal system for the underdrains in covered filters, because water which might pass down between the bed of sand and the masonry of the walls or piers, could not possibly escape from the filter without first passing laterally through the lower part of the sandbed. With open filters plan "B" will produce the same results.

In a locality where materials are easily procured and cheap, a system of underdrains by plan "C," with care in the placing of the layers of sand in the sandbed, should meet every practical requirement.



FIG. 17.—Interior of filters, showing lateral collectors and underdrain material.



FIG. 18. — Interior of filter showing underdrain material ready for reception of sand.

Above the gravel underdrains to a depth of 36 inches is placed the bed of filter sand. In placing the sand in a series of filters, some are filled to a depth of more than 36 inches, and some to a depth less than 36 inches, in order that the time of going out of service for resanding may not occur to more than one or two filters of a system at the same time. Thus, at Belmont,

3 filters will receive the sand for a depth of 28 inches.

3 filters for a depth of 31 inches.

3 filters for a depth of 34 inches.

3 filters for a depth of 37 inches.

3 filters for a depth of 40 inches.

3 filters for a depth of 43 inches.

An average depth for all filters of 35.5 inches.

The original depths of sand before the water is introduced and the sandbed settled, is about 6 per cent. more than the depths given.

In the thin beds the sand is placed in two layers, and in the thicker beds it is placed in three layers.

After the sand has been placed to the proper depth, the filter is slowly filled with water from below until it fairly covers the sand, and the bed allowed to settle for a period of ten days or two weeks. Afterwards the water is drawn down, and the depth of the bed then taken. Care in placing the sand has reduced the shrinkage by water settlement to as low as 4 per cent. That is, a bed originally 40 inches in thickness will shrink upon settling with water to slightly more than 38 inches, although the usual shrinkage amounts to about 6 per cent. of the original depth.

The sand used may be river or bank sand, provided it is well washed, and complies with the following physical requirements:

No particles should be intercepted by a No. 6 sieve, and but few particles should pass a No. 60 sieve. Such sand, by Massachusetts State Board of Health standard, will have an effective size of about 0.35 millimeter, and a uniformity co-efficient of about 2.50.

Experience with the Roxborough filters indicates no material difference in the work of the filters supplied with

river or bank sand, excepting that the river sand filters earliest give the best clarification of the water, and the bank sand filters earliest give the best bacterial results. After a few weeks of operation, however, it is difficult to detect any difference of performance which might be attributed to the source of the sand.

The cleanliness of the filter sand when first placed must comply with the following requirements:

When 100 grams of river sand are thoroughly shaken up



FIG. 19.—Filter entrance and regulator house.

in a beaker containing 1 liter of distilled water (or filtered water showing 0 + turbidity), the resulting turbidity of the water shall not exceed 400 parts per million by the silica standard, and, when 100 grams of bank sand are similarly tested, it shall not show a turbidity of more than 200 parts per million by the silica standard. Sand shall show not less than 95 per cent. silica, calculated as oxide of silica, and not more than 1 per cent. of lime and magnesia taken together and calculated as carbonates.

Bank sand being always lighter in color than river sand, has an advantage, when the filters are scraped, in striking a sharp line of division between the clean and dirty sand.

Experience at Roxborough shows the sand scrapings to average about 1 inch in thickness, and the theory that a thin layer of sand at the surface of the bed does nearly, if not quite, the whole work is abundantly proven by the scrapings of these filters.

Fig. 19 shows one of the regulator houses built over the influent and effluent chambers of the filters, and the entrance to a filter. The houses and filter entrances are uniform in design for all the filter works. Roman size brick has been used in all face work, and the best quality stretcher brick for inside linings. Cut stone, Eastern grey granite; terracotta belt courses and architraves; copper cornices, gutters and roof flashings; copper ridge and hip rolls and slate roof covering. The floors of all regulator houses are made up of iron plates laid on rolled "I" beams; perforated plates being used over the dry or influent chambers, and solid plates over the wet or effluent chambers. The "loss of head" gauges, which show automatically the difference of water levels over the sandbeds and in the effluent chambers, are mounted in the regulator houses.

THE CLEAR-WATER BASIN.

(Contract No. 16.)

The clear-water basin, which receives the effluents from all the filters, is located at the southeast corner of Monument Avenue and Ford Road. The basin measures inside on neat lines, 396 feet long by 382 feet 2 inches wide. This detail is constructed like the filters, with a concrete floor, concrete piers to support the roof, and concrete groined arched vaulting, above which is placed a covering of earth about 24 inches thick at the crown of the arch. The puddle layer under the floor is 12 inches in thickness. Floor inverts, 6 inches thick at the center and 14 inches thick under the pillars. The piers are plumb 22 inches square and 14 feet 4 inches high. Depth of water, center of inverts to spring of

arches, is 15 feet. Clear span of roof arches, 14 feet. Rise of arch, 3 feet.

The filtered water is conducted to the clear-water basin through a line of 48-inch cast-iron pipe in Monument Avenue, which enters the basin at the northeast corner. In the chamber where the influent pipe terminates, a 30-inch overflow pipe is located which will limit the depth of water in the basin to 15 feet 10 inches. The elevation of normal flow line in the basin is 239'00 C.D., but this at times may be temporarily increased to 239'83 C.D. The flow line of the present George's Hill Reservoir in the West Park is 212'00 C.D., so that the clear-water basin which in the future will furnish the head for the West Philadelphia lower service, is 27 feet higher than the old distributing reservoir. The Belmont clear-water basin will have a capacity at 15 feet depth of water of 16,500,000 gallons.

In the plans provision has been made for the construction of another basin of the same capacity directly north of the basin shown, but it is possible that in the future operation of the works the additional basin may not be required for many years, certainly not until after the consumption of water from this station exceeds 60,000,000 gallons per day.

The effluent from the basin is taken through a 48-inch cast-iron pipe located at the southwest corner, which leads into Monument Avenue, and is connected with a 48-inch line of pipe, known as line "K," and placed under Contract No. 19, which leads southward on Monument Avenue to Belmont Avenue, and on Belmont Avenue to Montgomery Avenue, where it is connected into the present rising pipes from Belmont Pumping Station to the George's Hill Reservoir. When the Belmont works are started, and the whole supply of West Philadelphia is coming from the filters, the connection of the rising mains with the reservoir at George's Hill will be cut out, and these pipes thereafter will form a part of the distribution system. Ample provision has been made at the intersection of the new mains from the clear-water basin with the old rising mains in Belmont Avenue at Montgomery Avenue, to prevent unfiltered water from

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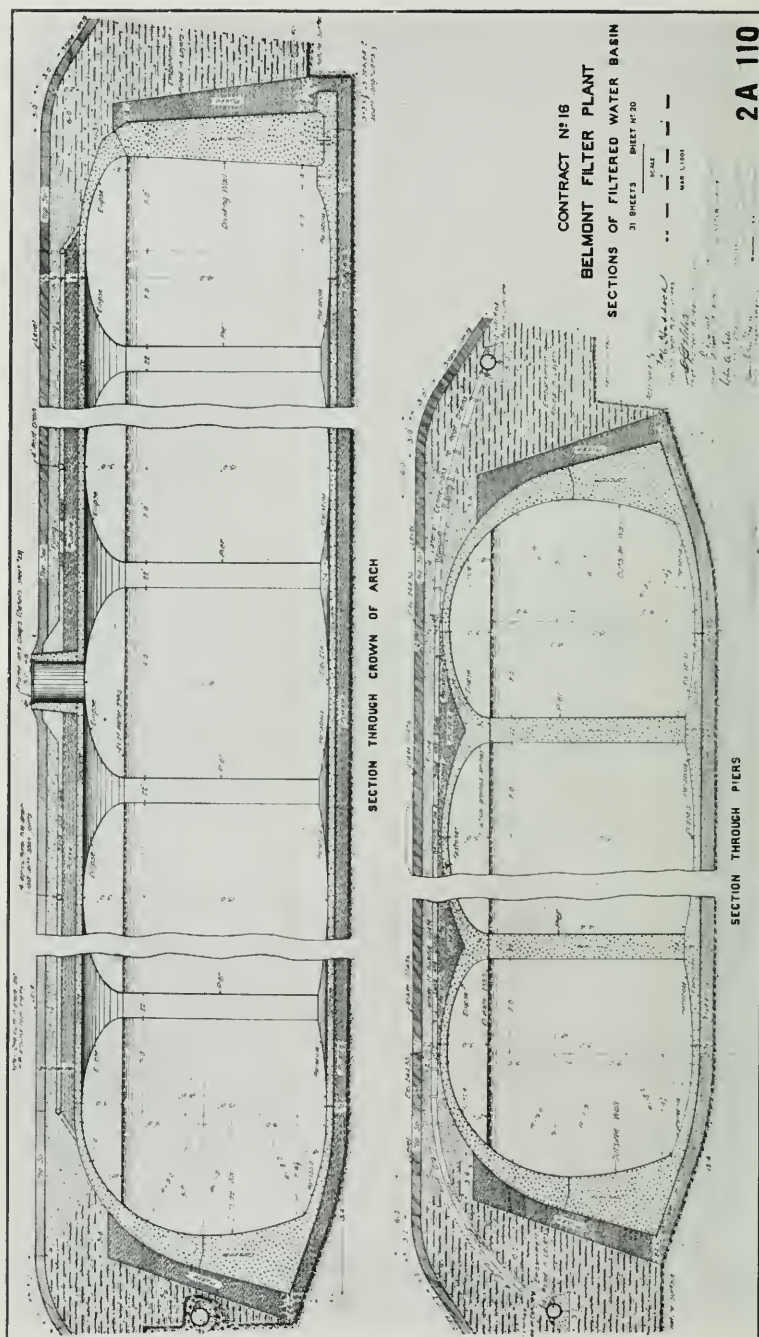


FIG. 20.—Sections through clear-water basin.

the Schuylkill River mixing with the filtered water coming from the filter station.

The effluent pipe starts in the floor of the clear-water basin with a bell-mouth casting to reduce the resistance of entry.

Drains connected with the sewer in Monument Avenue are provided to permit of emptying and examining the basin. At such times a by-pass connection from the main effluent pipes in the court lying between the group of filters 7 to 12 and 13 to 18, to the 48-inch distributing main in Monument Avenue, enables the filters to temporarily discharge their effluents directly into the distribution system. The only object in cutting out of service the clear-water basin will be to repair some damage, because it will only receive filtered water, and of course will never require cleaning. It is thought that this basin, after it is properly started in service, may never be taken out of service, excepting tests should be desired to prove its continued watertightness.

The puddle lining under the floor and against the side and end walls to the extreme water line is sharply shown by *Fig. 20*. It is not admissible to pass the water which may percolate through the earth filling over the clear-water basin into the basin to mix with the filtered water, and sub-soil drainage was therefore provided to remove this water and discharge it into the sewers. The spaces between the arches and over the piers were solidly rammed with a rich puddle to prevent water from flowing through the material and collecting over the haunches of the arches, and the sub-soil drains, shown, will remove the water of percolation through the earth fill down to the upper surface of the puddle and crowns of the arches.

The upper surface of the fill is finished with a dressing of topsoil and seeded to produce eventually a turf over the roof. All slopes of the clear-water basin and filters are sodded. A few ventilator openings are provided in the roof of the clear-water basin to furnish light and ventilation when required, the covers of which are securely locked to prevent intrusion by mischievous or curiously inclined persons.

CLAY PUDDLE.
(Contract No. 16.)

The chief reliance for watertightness of the structures is placed in the clay puddle, which consisted, as manufactured for the Belmont works, of 50 per cent. by volume of clay and 50 per cent. by volume of ballast, which may be clean gravel or broken stone. The materials were mixed in horizontal screw-paddle pug mills, such as are used for tempering brick and tile clay. During the busiest part of the work, five of these machines were kept constantly in motion preparing puddle for the water-tight linings of the reservoirs and filters, and for packing around such lines of pipes as were placed in embankment.

The clay consisted of equal parts of a strong, heavy ferruginous clay obtained from Perth Amboy and Brunswick, in New Jersey, or from Charlestown, Maryland, and of a weak clay combined with small gravel obtained from Swedeland, Montgomery County, Pennsylvania. The heavy clay could not successfully be worked alone in the pug mill, and the weaker clay was added to assist in breaking up and tempering the heavy clay. The ballast generally was broken stone, which varied in size from $\frac{1}{4}$ inch to $1\frac{1}{2}$ inch in diameters. Mixtures were sometimes made, consisting of 1 part by volume of the strong clay, 1 part of the weak clay mixed with gravel, and 1 part of ballast.

The strong clay by rational analysis (Ulzer's method), which wrought the separation of the silicate of alumina and iron from the insoluble silica and other substances, showed by weight from 60 to 70 per cent. silicate of iron and alumina, which was regarded as the clay constituent of the material, while the weaker clay showed by the same method of test from 35 to 40 per cent. of silicate of alumina and iron as the clay constituent of the material. The mixture of clays usually yielded about 50 per cent. of the silicates of alumina and iron and 50 per cent. of silica and other insoluble substances. (A natural clay showing by weight about 50 per cent. of the silicate of alumina and iron could be used alone in the manufacture of puddle.) Using equal parts of clay and ballast, gave a matrix for the ballast about 25 per

cent. in excess of the voids in the mass of hard material. Many clays were examined for use in the puddle, varying from a micaceous loam to strong clays, and showing by uniform method of rational test from 20 to 70 per cent. silicate of alumina and iron. In all cases it was assumed that the iron present in the clay was a valuable constituent of watertight puddle.

While the clay and ballast was being worked through the pug mill, water was added in quantity sufficient to make a plastic mixture.

The puddle was placed in two or three layers of from 6 to 9 inches and rolled in place to a thickness of 4 to 6 inches. Puddle linings varied from 12 to 18 inches in thickness, and were always placed in the work in from two to three separate layers of uniform thickness, each layer being rolled to a solid, dense mass having great sustaining power before the next layer was spread. The least thickness of puddle lining, when rolled or rammed to proper elevation, was 12 inches.

When the rolling of any layer of floor puddle under the basins or filters was finally completed, the puddle was as solid and almost as hard as new concrete.

When rolling was inadmissible, as, for example, around the walls of the filter and the effluent and influent chambers and gate chambers, the puddle lining was used sometimes 24 inches in horizontal thickness, and solidly rammed in thin layers.

The value of the puddle as a water-tight lining for thin concrete sections, is shown by the following table containing the leakage under a head of 9 feet of the accepted filters at Belmont :

Filter No.	1	Leakage	970 gallons per day of	twenty-four hours
3	727			
4	970			
5	610			
6	243			
8	566			
9	728			
10	776			
11	582			
12	475			
17	868			
18	849			



FIG. 21. — Rolling puddle on reservoir slopes.

The standard of watertightness for the filters was a leakage of not more than 1,000 gallons in twenty-four hours, corresponding to a loss, based on the daily capacity of the filter, of 0.0228 (or $\frac{1}{44}$) of 1 per cent.

The puddle on the slopes of the sedimentation reservoir, which could not be rolled with ordinary grooved horse-rollers, or with the steam rollers used on the floors of the reservoir and filters, was rolled by the ingenious single horse-roller (*Fig. 21*) improvised by Mr. Lawrence O'Toole, the foreman for the contractors, Messrs. Ryan & Kelley. This consisted of 36 inches of a 20-inch cast-iron water pipe filled with concrete, to give weight, and convert the pipe into a roller. In the center of the concrete an iron axle was fixed which turned on bearings provided in the lower ends of two standards bolted to the under side of the shafts at the rear. Wrought-iron bands were shrunk on the pipe to make a grooved roller.

This apparatus, with the addition of a mule, constituted a roller which was worked around the slopes. The puddle was placed on the slopes in thin horizontal layers, and three of the "O'Toole" rollers were constantly worked over it.

The puddle was rolled by six horse-rollers, varying from 1 to 5 tons in weight, and two steam rollers weighing 6 and $7\frac{1}{2}$ tons respectively. The horse-rollers weighed each 1,000 pounds per linear foot of roller and upwards, and the steam rollers weighed about 2,000 pounds per linear foot of roller.

CONCRETE.

(Contract No. 16.)

Nearly the entire masonry, including the reservoir floor and slope paving, and the paving in the courts, foundations of the buildings and sand washers, was built of Portland cement concrete.

Concrete was used in the floors, piers and vaulting of the filters and in the clear-water basin; in the influent and effluent chambers, and everywhere within its adaptability, partly to facilitate the construction of the work, partly to economize in the cost, and partly to reduce the number of joints in the

structures. If other material than concrete had been used in much of the work, the time and cost of construction would have been largely increased, with no corresponding advantage to the works. Seventy-four thousand barrels of American Portland cement from the Star Bonneville, Lehigh and Atlas factories were used in the manufacture of concrete for Contract No. 16 alone, after the following proportions:

Cement by volume	1 part,
Sand by volume	3 parts,
Ballast by volume	5 parts.

Six-inch concrete cubes were molded from day to day, and crushed at the end of 30, 60, 90, 120, and 180 days, with the following results:

Average of all the cubes at the end of 30 days, 1,781 lbs. per sq. in.					
"	"	"	60	"	1,850 " "
"	"	"	90	"	2,021 " "
"	"	"	120	"	2,063 " "
"	"	"	180	"	2,210 " "

Considering the 90- and 120-day cubes, which best represent the concrete before being subjected to external stresses, the average is over 2,000 pounds per square inch. Very rarely did the cubes fall below 1,200 pounds per square inch.

Each cube was numbered and its location in the work entered in the records, and whenever any cube after ninety days' time showed a crushing strength of less than 1,400 or 1,500 pounds per square inch, the concrete in the structures of which it was a sample was drilled or cut into to determine its hardness and density, and in no instance was the concrete found in such a condition as to raise a doubt of its quality. Excepting the arches in the vaulting of the filters and clear-water basin, the concrete is nowhere severely stressed, and concrete much weaker than that usually employed in the construction of fire-proof floors, and steel-reinforced concrete beams, would meet all requirements of such work as that under consideration.

The cement used in the manufacture of concrete was furnished under the following conditions:

Specific gravity not less than 3.1 per cent.

Fineness retained on No. 50 sieve 0 per cent.

“ “ “ 100 “ 10 “

“ “ “ 200 “ 25 “

Initial set (determined with a Vicat needle), not less than 20 minutes.

Tensile strength of briquettes, consisting of one part cement, three parts standard quartz sand, one day in air and six days in water, 170 pounds per square inch; one day in air and twenty-seven days in water, 240 pounds per square inch.

The average of tensile strength for briquettes made of one part cement and three parts of standard quartz sand, as stated above, during the two years of construction work at Belmont, is about 200 pounds per square inch for seven days—one day in air and six days in water, and 300 pounds per square inch for twenty eight days—one day in air and twenty-seven days in water.

When the boiling test of cement was applied it was expected to show no disintegration of the egg-shaped sample.

No cement that failed to give the required strength at the end of seven days was allowed to go into the work for twenty-eight days, and if it failed to show the required strength at the end of twenty-eight days, it was rejected entirely, or its use was occasionally permitted at some point in the work where strength of concrete or mortar was not particularly desired.

The sand used in the manufacture of concrete was clean New Jersey bank sand; the ballast was broken limestone, ranging in any dimension from $1\frac{1}{2}$ to $\frac{1}{4}$ inch, thoroughly screened of finer materials. In the granolithic finish of concrete work, the proportions were one part cement, one and one-half part clean New Jersey bank sand, and one and one-half part limestone screenings; experiments in the City Laboratory having shown better results in point of strength for a mortar from limestone screenings than from quartz sand or New Jersey bank sand.

The percentage of water used in mixing concrete varied from 15 per cent. to 18 per cent. of the cement, sand and ballast by volume,

In the cubical box mixers used in this work, after the sand and ballast were introduced into the box, the materials

were turned from four to six times dry, and after the water was added the mixers were again turned from eighteen to twenty times.

A small portion of the concrete was mixed in a horizontal knife mixer, the knives or paddles being so arranged that they worked the materials from the ends of the box to the center, where it was forced up and over the knives at the center to the ends of the box, and again forced from the ends to the center, and so on, until properly mixed.

The capacity of the concrete mixing machinery was limited to 450 cubic yards per day, but the actual rate at which concrete was mixed and placed in the floors and slopes of the reservoir and in the floors of filters, and clear-water basin, was usually determined by the rate at which puddle could be mixed, placed and rolled. Directly the puddle was finished at any point, concrete was immediately placed over it.

In the floor sections of the filters on fill, expanded metal was freely used, so placed as to bond adjacent sections of concrete, and generally to strengthen that portion of the floor which it was assumed would be stressed by the loads the bases of the piers.

Each pier in the clear-water basin sustains at its base a load of about 64 tons, spread over an assumed surface on the puddle lining under the concrete of about 17 square feet, or the unit load on so much of the floor inverts as are supposed to resist and distribute the pier loads, is nearly four tons per square foot. The rolling of the subsoil or earth-fill preparatory to placing the puddle lining, and the subsequent rolling of the puddle, rendered this in all instances a good foundation for what are comparatively light loads.

When the foundation (in the clear-water basin) was not satisfactory, concrete sub-piers three feet square, and from six to eight feet deep or high, carried up from solid ground or from a grillage to the under side of the puddle, were built; the whole load on the pier was thus transmitted through the puddle to the sub-pier below.

The foundation under the concrete floors and the puddle

lining was rolled with grooved rollers, weighing about 3,300 pounds per foot width of roll.

With the exception of the piers in one filter, all concrete was rammed and finished in place. In Filter No. 1 the piers were fabricated as monoliths and set by a derrick.

ASPHALT RESERVOIR LINING.

(Contract No. 16.)

Over the concrete floor and on the slopes to a height 10 feet vertical below the water line, as shown by *Figs. 22* and *23*, a lining of asphalt $\frac{3}{4}$ inch thick was placed in two layers, each uniformly $\frac{3}{8}$ inch thick. For several reasons it is desirable that the subsidence basins be as nearly water-tight as such structures, constructed partly in embankment, can be made, and in addition to the outer lining of 18 inches of puddle and 6 inches of concrete floor and slope paving, it was deemed advisable to line the floor and slopes with an impervious coat of asphalt.

Two mixtures of asphalt were used, one containing the larger percentage of bitumen on the floor and first coat on the slopes, and the other, slightly lower in bitumen, in the second or finishing coat on the slopes.

The mixture of Neufchatel or Seyssel asphalt, Bermudez asphalt and grit, as specified in the contract, should contain about 18 per cent. of pure bitumen, but tests early indicated that such a mixture was too soft for use on the slopes, and probably not superior as a water-tight lining on the floors of the basins, and, under the provision of the specification, the percentage of bitumen was accordingly decreased.

The several mixtures tested contained as an average the following weight of materials for each batch that went into the kettle.

ASPHALT MIXTURE USED ON THE FLOOR OF RESERVOIR AND IN THE FIRST LAYER ON SLOPE.

585 pounds Seyssel mastic.

315 pounds grit.

50 pounds refined Trinidad asphalt.

50 pounds refined Bermudez asphalt.



FIG. 22.—Placing asphalt lining on floors of reservoirs.

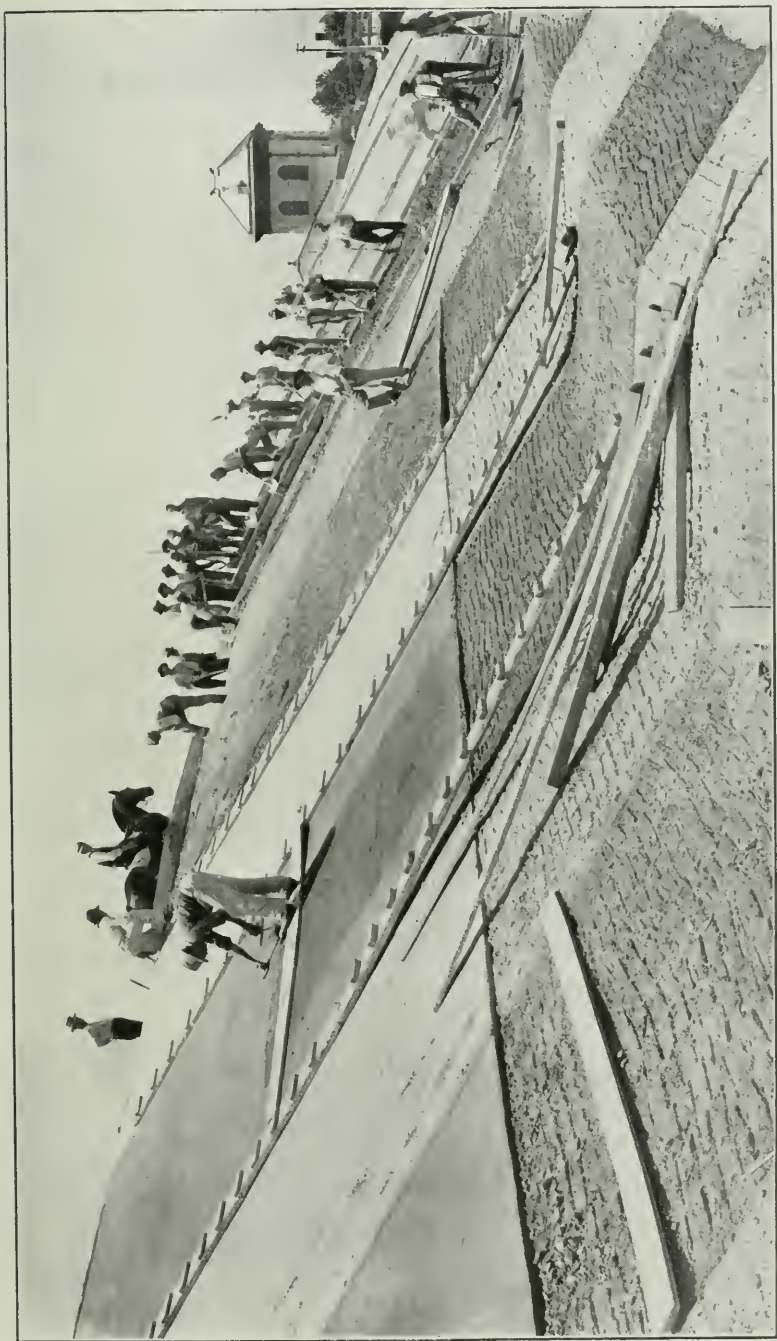


FIG. 23.—Placing asphalt lining on slopes of reservoirs.

ASPHALT MIXTURE USED IN SECOND LAYER ON SLOPES OF RESERVOIR.

598 pounds Seyssel mastic.
332 pounds grit.
33 pounds refined Trinidad asphalt.
37 pounds refined Bermudez asphalt.

The above mixture gave an average of 15.5 per cent. of bitumen for the lining on the floor and first layer on the slopes, and 13.2 per cent. of bitumen for the second layer on the slopes, the latter, of course, requiring a stiffer mixture to prevent or limit the creeping by action of the sun's rays, and likewise, of course, to avoid cracking due to the influence of the frost.

On the floor of the basins, the asphalt was laid on the smooth concrete, but on the slopes the concrete was roughened by indenting grooves $\frac{1}{2}$ inch deep and $\frac{3}{8}$ inch wide, spaced about 4 inches center from the toe to the top of the asphalt line, to secure the asphalt against slipping or creeping on the concrete.

The watertightness of the asphalt, concrete and puddle in the reservoirs is still to be tested, but I have no doubt that they will be as near water-tight as structures as large as these can very well be made. Generally, of course, we cannot expect earthen embankments, however carefully they may be lined with impervious materials, to be absolutely water-tight, but I anticipate that the measured leakage of these basins will show such a small percentage of loss as to indicate practical watertightness.

It is possible that the asphalt lining might have been omitted without seriously affecting the watertightness of the reservoir; but, considering the height to which the water is pumped from the Schuylkill River, and the nature of the surroundings, it was thought wise to omit no precautions to insure the nearest approach to absolute watertightness of the structure.

[To be concluded.]

ELECTRICAL SECTION.

Stated Meeting held Thursday, October 8, 1903.

Rail Bonds.

BY W. E. HARRINGTON.

General Manager Camden and Suburban Railway Company.

(Continued from page 70.)

Paulus Rail Drill. The Paulus automatic feed drill, *Fig. 17*, is a device by which the operator is able to stand in an erect position while drilling holes in the rails. Illustration shows drill for T-rail work. Weight, 60 pounds. Made for girder rail.

Buda Heavy-Base Rail Drill. The Buda pattern drill, *Fig. 18*, is similar to the Paulus in construction, but is much heavier for use in drilling heavy T-rails. Weight, 90 pounds.

Electric Drilling Plant. This is an equipment for rail drilling, *Fig. 19*, where current can be taken off the trolley wire. It is compact, easily transported and will do the work in a fraction of the time required with hand-power drills. The motor used is of a multispeed iron clad type, having an approximate speed of from 750 to 1,700 revolutions per minute. All of the notches are available for intermittent work, and the motor can be run continuously on the last two. The plant consists of the following details:

- 1 One H.P. electric motor complete.
- 1 Flexible shaft.
- 1 Universal joint.
- 1 Track drill press.
- 1 Track old man.

"ALL-WIRE" RAIL BOND.

The "all-wire" rail bond is made entirely from one piece of flexible copper cable, which is cut to length, as shown in *Fig. 20*.

It is then placed in a forming machine and the ends of the cable are cold pressed into shape for the terminals, as

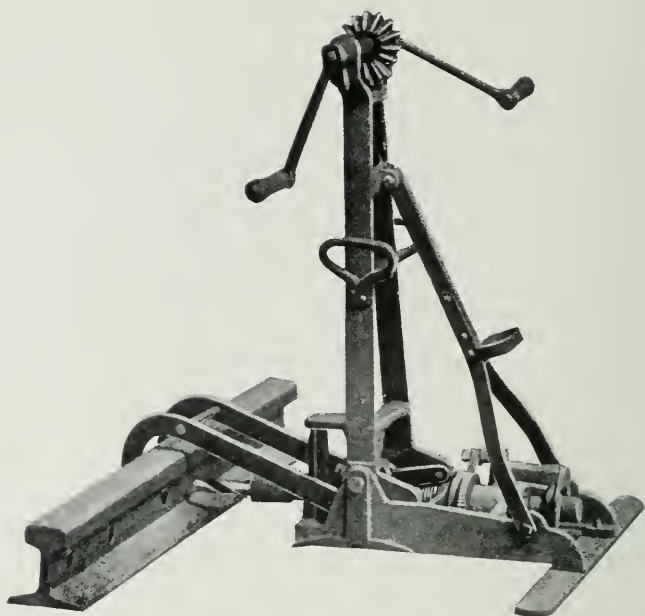
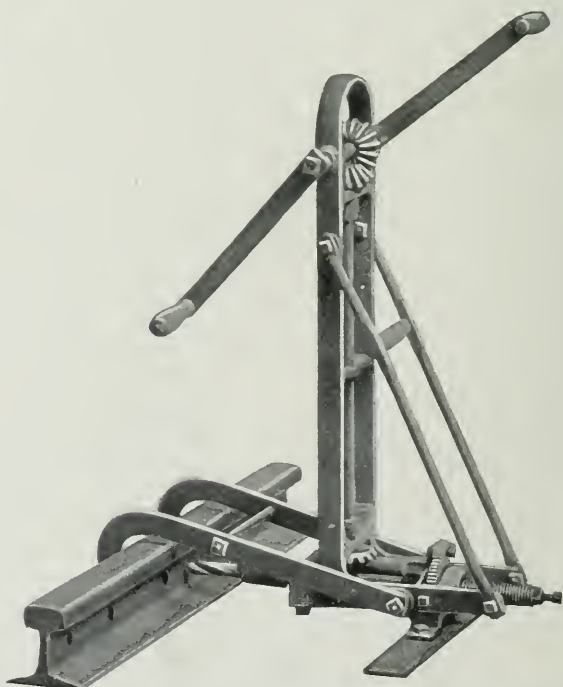


FIG. 17.—Paulus rail-drill. In position for drilling.



[FIG. 18.—Buda heavy-base rail drill. In position for drilling.

illustrated in *Fig. 21*. In this form the strands of wire in the terminals are compressed firmly together, as the illustration shows; the size of the terminals, however, being considerably larger than in the finished bond.

The ends of the bonds are then heated to the welding point and pressed approximately to size and shape in a steel die. In the latter process the size of the terminal is considerably reduced, the wires composing it being perfectly welded together and forming a mass of solid copper. The terminals are then placed in a trimming die and finished

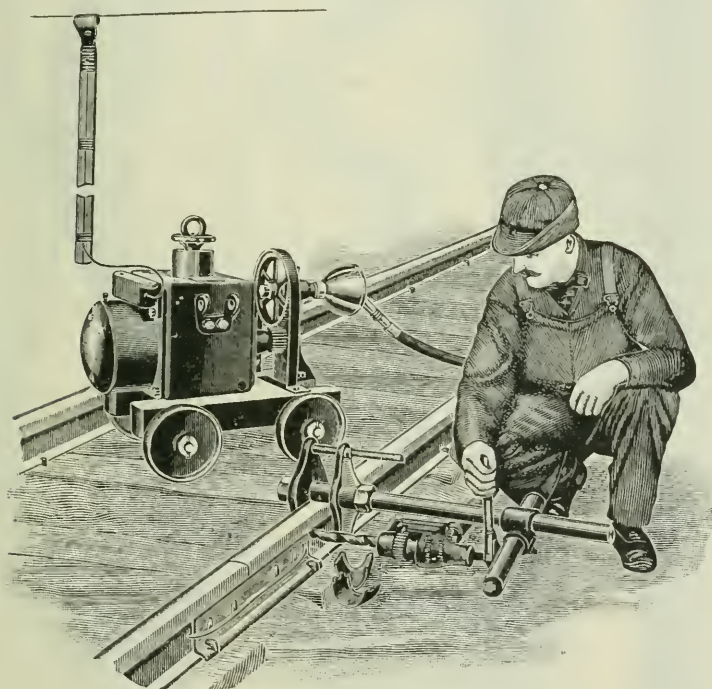


FIG. 19.—Electric drilling plant.

accurately to size. *Fig. 22* shows the appearance of the finished bond, and illustrates the perfect manner in which the wires of the cable are gradually merged into the solid copper terminals.

Figs. 23 to 27 exhibit different types of the "all-wire" rail bond.

"CROWN" BONDS.

The "crown" bond of the flexible type is made of drawn copper with the heads or terminals welded to the strand.

Fig. 20, a, b, c, d, e, shows in detail some of the mechan-



FIG. 20. — "All-wire" rail bond. Cable, cut to length.



FIG. 21. — "All-wire" rail bond. Cable, cold pressed, ready for welding.



FIG. 22. — "All-wire" rail bond. Finished bond.

ical features which are common to all styles of "crown" bonds.

Fig. 28 a, shows the steel expanding pin used with all "crown" bonds. This pin is made larger than the hole in the terminal, so that, as it is driven into the terminal it is

intended to press the copper outward in all directions radially from the center line of the pin.

Fig. 28 b, gives a full view of the terminal of a "crown" "S" (solid) bond, drilled and milled ready for insertion in the web of a rail.

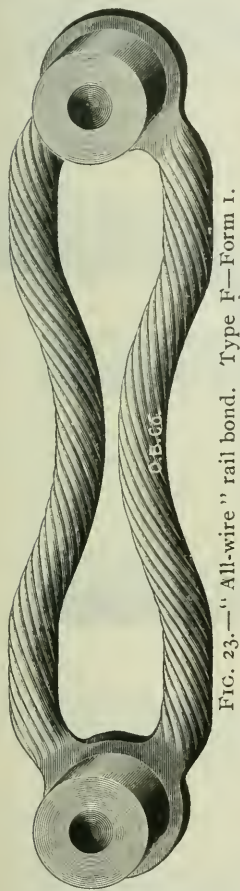


FIG. 23.—"All-wire" rail bond. Type F—Form 1.

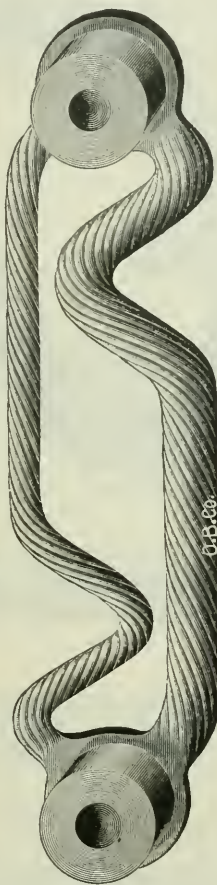


FIG. 24.—"All-wire" rail bond. Type F—Form 8.

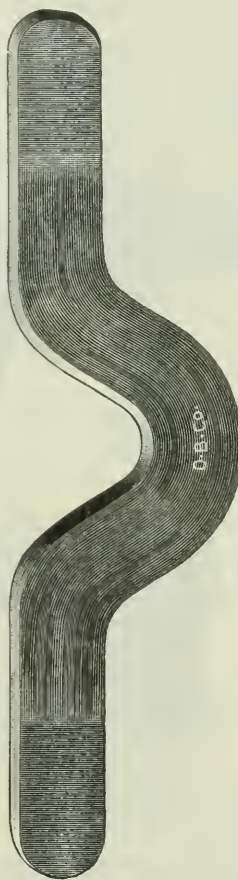


FIG. 25.—"All-wire" rail bond. Type G—Form 2.

Fig. 28 c, shows in cross-section the same terminal fastened within the web of the rail.

Fig. 28 d, shows a full view of the terminal of a flexible bond, which is the style of terminal used on all standard "crown" bonds.

Fig. 28 e, shows in cross-section the same terminal fastened within the web of a rail. Cuts *c* and *e* show that the

pin in being hammered home has expanded the copper on the further side of the web to form a burr. No special tool or extra work is required to produce this burr, which effectively fastens the terminal, serving the purpose of a shoulder or riveted head.

The "crown" bond is applied easily and economically. The bond is slipped into place in the rail and the expanding pin driven in. The copper of the terminal is expanded radially into contact with the steel.

As the result of experiments a force of 13,500 pounds

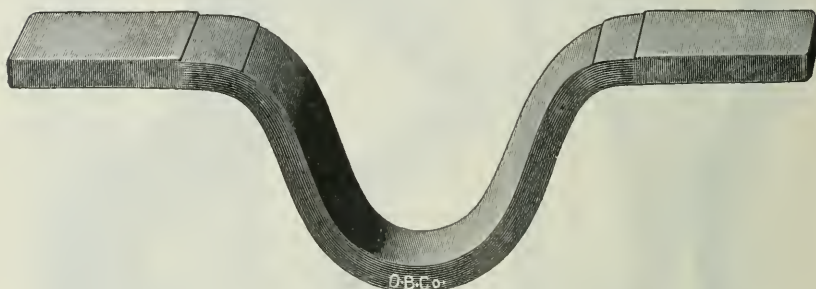


FIG. 26.—"All-wire" rail bond. Type G—Form 1.

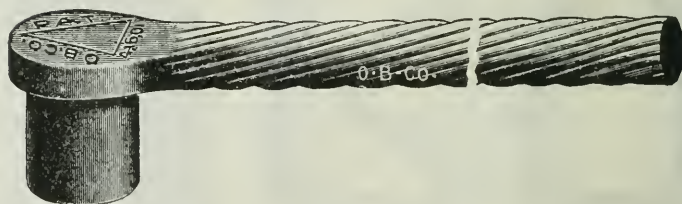


FIG. 27.—"All-wire" bond terminals.

exerted through the medium of an expanding pin of proper form and size, will produce as perfect contact between copper and steel as a force of 48,000 pounds applied by means of a hydraulic press such as is commonly used to compress the terminal of a bond within the rail.

Figs. 29 and 31 show shapes designed for use between the web of T- or girder-rails and the splice bars. It is designed to span one, two or more bolts as desired. In *Fig. 37*, *a* and *b*, the loop holes for the bolts are so located that the holes for terminals are placed between the first and second bolt

holes. The number of loop holes and their relation relatively to the terminals and to each other may be varied to meet all arrangements of bolts and bond holes. At least 2 inches

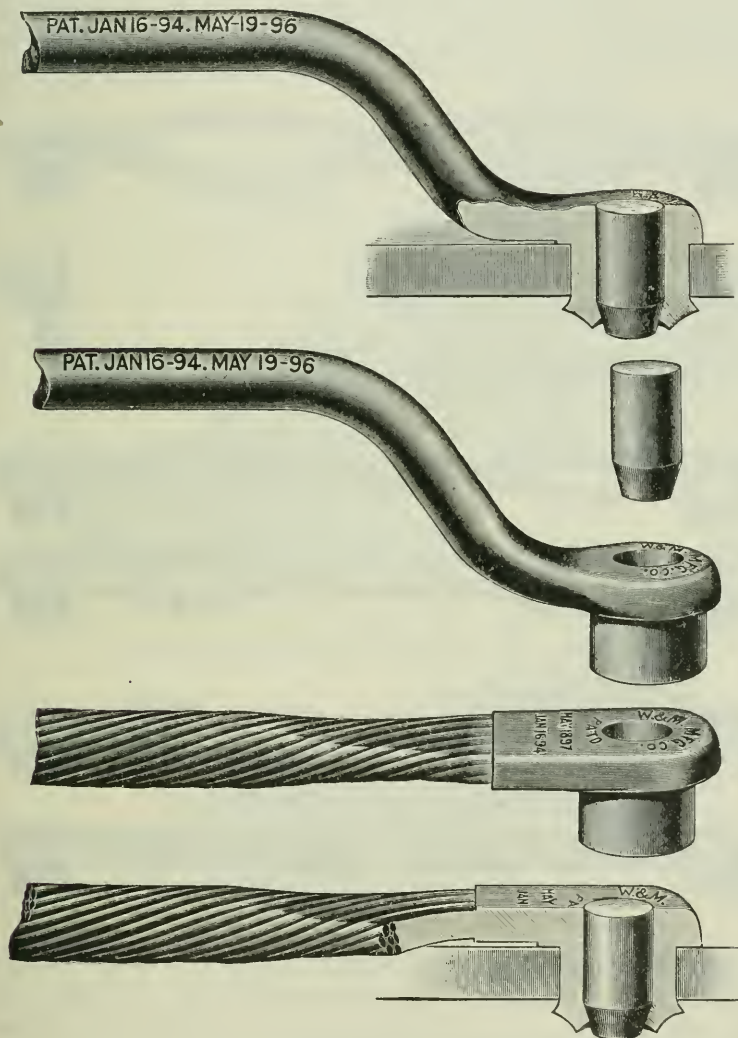


FIG. 28.—Crown-bonds. *a, b, c, d, e.*

between the center of the bolt hole and the center of the bond hole are always desirable.

The two strands may be the same size, as in sketch *Fig.*

31 *a*, or one strand may be larger than the other, as in sketch *Fig. 31 b*. In either case the sum of the capacities of the two strands will equal the capacity of the required bond.

Fig. 32, a and *b*, shows a bond made with flexible strand, either straight or crescent-shaped between the terminals. In both cases every wire in the strand is made with a curve



FIG. 29.—“Crown” figure 8 bonds



FIG. 30.—“Crown” S (solid) cross-bond

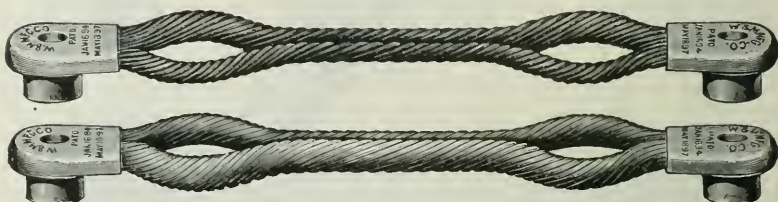


FIG. 31.—“Crown” duplex parallel strands bonds, *a*, *b*.



FIG. 32.—“Crown” T-bonds.



FIG. 33.—“Crown” F (flexible) bond.

which gives flexibility and permits elongation of the strand itself without tension on the individual wires. In the crescent-shaped “crown” T-bonds, the curve of the strand permits the terminals to spring farther apart or close together when the rails contract or expand.

In the straight bond, to provide additional length of each wire to compensate for the contraction of the rails, the

strand is pressed back so that it bulges sidewise midway between the terminals.

This makes the wires long enough for the terminals to be drawn apart $\frac{3}{4}$ of an inch without putting the individual wires in tension. When the rails expand, the already curved wires will close together more tightly and the

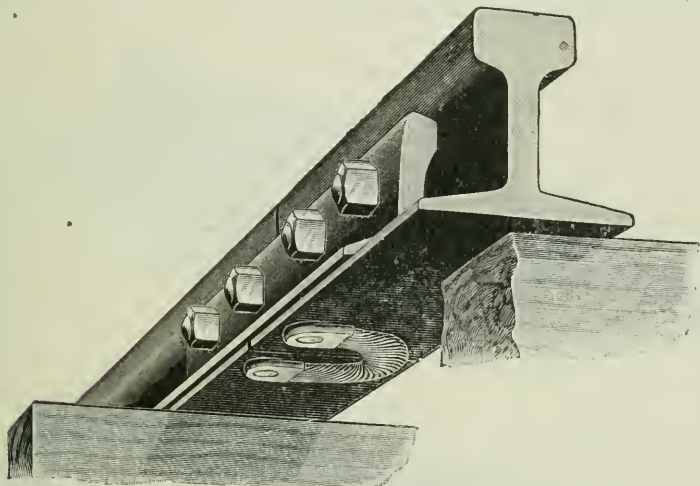


FIG. 34.—“Crown” U bond.

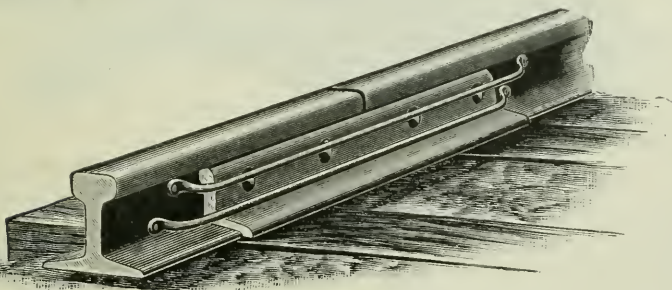


FIG. 35.—T-rail with two “Crown” S bonds.

terminals may come $\frac{1}{2}$ inch nearer together without distorting the bond.

In *Fig. 33* the terminals are welded to the strand.

Fig. 34 exhibits a shape designed for use under the base of a T- or girder-rail, or behind the splice bar on a high T-rail. As regularly made, the distance between centers is 3

inches, but the shape admits of a ready adjustment to holes up to $5\frac{1}{2}$ inches between centers.

Fig. 35 shows a T-rail bonded with two "crown" S bonds and *Fig. 36* a T-rail bonded with two "crown" F bonds.

Fig. 37 shows "crown" F bond applied to the conductor rail of an underground or conduit system. The "crown" bond has been used upon the underground systems of the

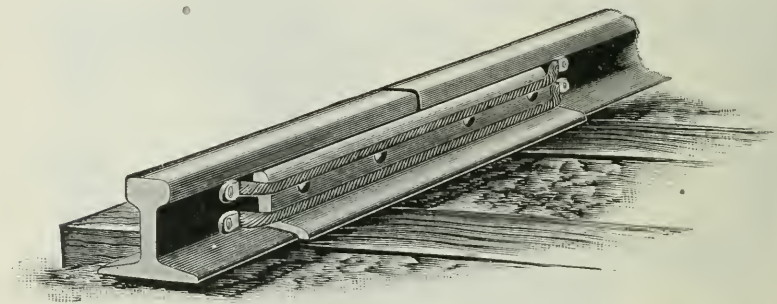


FIG. 36.—T rail with two "Crown" F bonds.

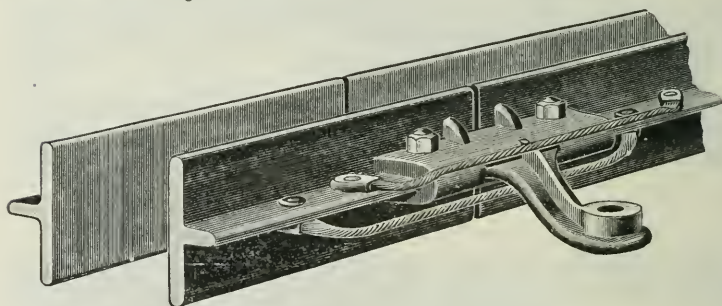


FIG. 37.—"Crown" F bond on underground system.

Metropolitan Railroad, Washington, D. C., the Capital Traction Company, Washington, D. C., the Third Avenue Railroad of New York City, and the Metropolitan Street Railway Company of New York City.

(To be continued.)

THE LARGEST METEOR.

The Smithsonian Institution's expert, F. W. Crosby, examined the meteor which fell at Lodi, Cal., and pronounces it not only genuine, but likewise the largest ever found in the United States. It weighs between 10 and 20 tons. From all appearances it seems to have been buried in the hill, where it was found, for many years.

Mining and Metallurgical Section.

Stated Meeting, held Thursday, January 7, 1904.

Recent Investigations and Discoveries in Cast Iron.

BY ALEXANDER E. OUTERBRIDGE, JR.

It is my purpose this evening to describe in an informal manner the results of some investigations of hitherto unobserved properties of cast iron. As cast iron is one of the oldest and most universally used metals known to the engineering profession, it would seem almost hopeless to expect to be able to find at this late day any important characteristic properties which have escaped observation and study, but I hope to prove to you that we have still a good deal to learn about the peculiar properties of this metal as distinguished from those of wrought iron, steel, or indeed any other metal or combination of metals.

It was my good fortune a few years ago to bring to light some interesting and, I believe, quite valuable properties of cast iron not then known; the new observations now to be described have grown out of those studies and have a close relation thereto, though differing radically in many respects.

In a paper entitled "The Mobility of Molecules of Cast Iron," presented to the American Institute of Mining Engineers, at its annual meeting in February, 1896, the following introductory statement was made:

"It has been generally accepted as a fact that cast iron, under the influence of repeated shocks, becomes brittle, and will finally break under a blow which otherwise it would have withstood. It will probably surprise metallurgists, therefore, to learn that experiment disproves the supposed fact, and establishes exactly the opposite. The result of about 1,000 tests of bars of cast iron of all grades, from the softest foundry mixtures to the strongest car-wheel metal, enables me to assert with confidence, that, within limits, cast iron is materially strengthened by repeated shocks or blows."

This surprising statement immediately attracted the closest attention from founders, manufacturers, engineers and scientists both in this country and in Europe. Crucial tests were made by many independent investigators under varying conditions and with all grades of cast iron. The technical papers contained numerous reports, all corroborative of the original statements, but showing much larger gains in strength than those claimed in the tables of tests appended to the paper. This did not at all surprise me because I knew from my own records obtained, but not published at that time, that my statements were exceedingly conservative. I feared that my largest gains, if published, would seem incredible, and I realized that the maximum figures given in my tables (approximating 20 per cent. increase in strength of bars subjected to mechanical shocks, as compared with untreated companion bars) would fully suffice for the purpose of establishing my claims, and I preferred that others should find still larger gains in strength on repeating the tests.

The Franklin Institute appointed a committee of experts to investigate the subject; they made and tested a large number of bars, and their report was published in the *Journal of the Institute*, July, 1898. The tables of tests in this report, covering eighty-two bars, show a maximum gain in strength of molecularly annealed bars (free from all defects), as compared with companion bars (also free from defects) untreated, amounting to 40 per cent. and a maximum gain in resilience, or bending quality, of 41 per cent.

Two important practical results have come from the publication of those investigations; one is the great increase in the practice of tumbling castings, and decrease in the practice of pickling them to remove sand burnt upon the surface, subsequent tests having shown that cast-iron bars immersed in the ordinary pickling solution (sulphuric acid and water) are weakened to the extent of about 10 per cent. as compared with companion bars not pickled, while castings cleaned in the tumbling barrel are always strengthened materially.

In Europe, tumbling barrels of very large size have been

constructed *provided with two rates of revolution* to permit of obtaining the best results. An English writer on "Foundry Practice in the Twentieth Century," Mr. Robert Buchanan, shows photographic illustrations of such apparatus in a paper (one of a series) published in the *Engineering Magazine*, May, 1903, and gives a very gratifying report of the practical value to the foundry industry of the discovery of molecular annealing of castings.

Another interesting application of this discovery has been the introduction of a clause in certain specifications for iron castings requiring that "the test bars must not be tumbled or otherwise subjected to shocks prior to being tested, but must simply have the adhering sand brushed off." The latest instance of this kind may be found in the specifications for gray iron castings recently formulated by a committee of The American Society for Testing Materials.

It thus appears that the heretofore unobserved, though characteristic, property of cast iron, of increasing in strength under the influence of shocks, has now become well known and recognized as a fundamental law governing the behavior of that metal and differentiating it in this respect from steel and all other metals under repeated shocks.

Another new observation quite as unexpected and surprising, perhaps, to metallurgists and engineers, growing out of these original studies and tending to corroborate the theory then advanced regarding the mobility of molecules of cast iron, is to be announced to you this evening.

Before proceeding to do this, however, I will ask your kind permission to indulge in a few reminiscences of a somewhat personal nature, as I think they have a close relation to what I am about to describe regarding my most recent experiments, and it is one of the compensations of advancing years to find that one's recollections of experiences of former days begin to acquire a certain interest, if not value, to a younger generation. My introduction to the study of cast iron dates back to the Centennial year, and in 1876 the total production of pig iron (as given in Mr. Swank's statistical tables) was 1,868,961 tons. In 1903 the production exceeded 18,000,000 tons, or ten times that of 1876.

Coincidentally with this enormous increase in production during these years came a large increase in the proportion of so-called "metalloids" in pig iron, viz., silicon, sulphur, phosphorus and manganese and corresponding change in the character of the metal.

I remember, for instance, the time when it was considered that anything over 1 per cent. of silicon in pig iron of No. 2 grade was rather high. Now, 1 per cent. of silicon in this grade of iron is considered rather low. It is probable that if we could ascertain the average proportion of silicon in all of the iron produced in the United States in 1903 we would find that it approximated 2 per cent. If this be correct it follows that there was produced in that year the enormous amount of 360,000 tons of silicon in the pig iron made, statistical returns of which will not be found in any of the published tables of production of metals and minerals in the United States, for it was all concealed in the iron, and was either burnt up in the converters, or in open-hearth steel furnaces, or else entered into the composition of miscellaneous castings made from this pig iron.

At the time of my initiation into the metallurgical work of an iron foundry, the quality and value of pig iron was determined by its fracture; a large open grain dark gray fracture was graded as "No. 1" iron, a closer grain metal was classed "No. 2," and so on down the scale; a variation of fifty cents, or sometimes \$1.00, a ton in the price of the different grades usually prevailed. In order to study the methods of grading iron at the fountain head, I visited, in 1881, a number of blast furnaces in Pennsylvania and other States, spending a few days or a week, as the case might require, at each. At one of the first of the large plants I inspected (long since defunct, but at that time a leading producer, with several stacks in operation), I obtained my first insight into these mysteries. Although it was summer weather, the casting-house was kept tightly closed and was consequently insufferably hot. Boards were placed over the hot sand to enable the negro laborers to walk over it, and as soon as the pigs of one cast were removed, new pig beds were made up, even before the sand

became cool enough for me to touch. On inquiring of the "boss" of the casting house why they did not open the doors to allow the steam to escape and the sand to cool quickly, he replied, "Why, you don't know nothing about making iron—it would cost us fifty cents a ton to do that, for all our iron would grade No. 2 instead of No. 1."

Here was a revelation, indeed, and from that day to this I have refused to regard the fracture of pig iron as a safe guide to its composition and value.

In a review of progress in the metallurgical arts for the year 1881, printed in a magazine called *The Penn Monthly*, February, 1882, I ventured to make the following prediction:

The improvements in the manufacture of iron and steel have been not less marked. The introduction of hotter blast has enormously increased the capacity of furnaces in the production of pig iron, and has lessened the cost. The chemistry of iron is being studied more carefully. Manufacturers are beginning to realize that pig iron is not a simple element, but is, in reality, composed of a number of substances; that its physical characteristics, such as strength, elasticity, etc., depend upon the percentages of these constituents, and that pure iron, like pure gold, is always the same thing, physically and chemically, no matter from what source it may be obtained. I believe that the time is coming when pig iron will be sold on its chemical analysis, instead of on the crude methods of grading, at present in vogue. And further, that, as the naturalist can tell the genus of an animal from an examination of a single bone, so the chemist will tell the characteristics of a mass of iron from the analysis of its component parts.

The supplanting of empirical by scientific metallurgical methods in foundries has progressed rapidly during the past ten years or so, and the recent substitution of "machine cast pigs" (cast in iron molds) in place of pigs cast in sand, has given the death-knell to the crude and obsolete methods of grading pig iron by fracture, in vogue in my youth.

Formerly the founder depended upon buying "strong" pig iron to obtain strong castings, and certain brands were celebrated on this account, bringing fancy prices, being thought quite indispensable for some castings. Most, if not all, of the famous old furnaces have gone out of existence and the progressive founder now depends upon his metallurgist to produce castings suitable for all his purposes from pig iron of heterogeneous composition. The metallurgist pays but little regard to the fracture or even to the strength

of the pig iron in the yard. He knows that the quality of the metal at the spout of the cupola depends upon a proper relation between the different component elements and that one or two of these practically control the character of the iron.

It is a common practice to-day in modern "up-to-date" foundries to draw, from one cupola in one heat, soft metal suitable for the smallest pulleys or other light castings, having tensile strength of 19,000 to 22,000 pounds per square inch, in test bars of 1-inch square section, 15 inches long, and iron of very different character, suitable for large castings, weighing perhaps 30 tons or over, having tensile strength of more than 30,000 pounds per square inch.

Recently an unusual metallurgical problem was presented to me demanding special treatment. Some small hollow castings were required for experimental purposes, about 18 inches long and $\frac{1}{2}$ inch thick, to withstand bursting strains under high-steam pressure. The peculiar requirements were that the metal must be fine grained, perfectly gray, absolutely soft, free from hard spots or "chill" and, to a certain extent, malleable. Four test bars 15 inches long and of the same thickness as the castings, molded on either side of each casting and attached thereto, were required to show tensile strength, when turned to a diameter of about .35 inch between threaded ends for the grips of the testing-machine, of not less than 30,000 pounds per square inch. This proposal was, I believe, submitted to and declined by several manufacturers who considered the conditions impracticable. The castings were made in the foundry of William Sellers & Co., Inc., and the following is a copy of a record furnished to me by the operator of the 100,000-pound hydraulic testing-machine of six test bars attached to six castings, all made on different days:

No.	Diameter.	Pounds per Square Inch.
1	.310 inches.	41,842
2	.310 "	40,533
3	.375 "	42,363
4	.342 "	43,260
5	.312 "	44,210
6	.342 "	44,565
Average	.332 "	42,795

It should perhaps be stated that there was no maximum limit of strength named, providing that all of the other conditions were maintained, and the test bars were not subjected to any treatment after being removed from the molds. The broken test bars are now submitted for your examination.

The reason for making the test bars of the same thickness as the castings and for molding them in as close proximity thereto as possible, causing them, in fact, to form a part of the casting, was, of course, to have all the conditions, such as rate of cooling, etc., alike in both, since the strength of test bars depends largely upon the rate of cooling of the metal. In order to determine this fact accurately I have made many experiments. In one case (which I have described elsewhere) I cast a solid cube of iron 15 x 15 x 15 inches, which was cut up into eight slabs 1 inch thick and these again into eight test bars of 1 inch square section. The bars were all numbered serially, making sixty-four bars in all; these were broken transversely in the testing-machine; the average strength of the bars cut from the exterior portion of the block exceeded the average strength of the interior bars by more than 50 per cent.

In another experiment four round bars were cast on end from one ladle of iron—all were 15 inches long; two were $1\frac{5}{8}$ inches diameter in the rough, and two were $1\frac{1}{4}$ inches diameter; the larger bars, which cooled somewhat more slowly than the smaller bars, when turned and pulled showed tensile strength (average) of 29,100 pounds per square inch. The smaller bars gave tensile strength (average) of 33,180 pounds per square inch—a difference of 4,080 pounds per square inch. Other similar tests gave similar results.

We do not find variations at all comparable with this in cast steel bars of the same dimensions, and the reason is not hard to find. In gray cast iron the molecules or crystals of iron are comparatively loosely tied together, the intermolecular spaces being filled with "free carbon," which may be readily brushed out from a freshly fractured surface with a common whisk. In ordinary steel there is no free

carbon, and the molecules are more closely united, hence the greater specific gravity of steel. The molecules of cast iron being far more mobile than those of steel tend to arrange themselves farther apart when the mass of molten metal cools slowly than when it cools rapidly, hence the more open grain, and tests show that the specific gravity of a mass of gray cast iron which has been rapidly cooled is always higher than the specific gravity of a mass of the same metal cooled more slowly. The denser the iron the higher is the tensile strength.

My purpose in stating these facts, some if not all of which are, no doubt, well known, is to lead you by logical steps up to the consideration and comprehension of some recent observations respecting the mobility of molecules of cast iron, which, I venture to think, will prove both novel and surprising.

I now present for your close inspection two companion test bars which were cast from one ladle of iron in one mold, from patterns of the same dimensions, viz., 15 inches long and 1 inch square section. In order to avoid possible variations due to "rapping" of the patterns, the ends of the molds were formed by iron yokes, accurately machined to 15 inches between the ends of the yokes, inserted in the mold. (See cut No. 6.) When the bars were cleaned and measured they were found to be $14\frac{1}{8}$ inches long and 1 inch square section. One bar remains exactly as cast, *the other has been caused to grow gradually in cubical dimensions* until now it is $16\frac{1}{2}$ inches long and $1\frac{1}{8}$ inches cross-section! A portion of one side of this bar has been machined in order that you may examine the finished surface, and you will observe that, notwithstanding the surprising increase in bulk—exceeding 40 per cent. over the original dimensions—it has lost none of its metallic qualities and presents a beautiful lustre and fine-grained, smooth surface.* This bar weighs precisely the same as it did before it had been caused to grow

* Dimensions of bar before treatment, $14\frac{1}{8} \times 1 \times 1$ inches; contains 14·8125 cubic inches. Dimensions of bar after expansion, $16\frac{1}{2} \times 1\frac{1}{8} \times 1\frac{1}{8}$ inches · contains 20·8828 cubic inches. Expansion in volume, 40·98 per cent.

no less than $1\frac{1}{16}$ inches in length and $\frac{1}{8}$ inch in cross-section, but the specific gravity is, of course, less than before.

A section, $\frac{1}{4}$ inch thick, of a similar test-bar before expansion, was found to have a specific gravity of 7.13. A cubic foot of this metal weighs, therefore, $444\frac{3}{4}$ pounds. A similar section of the same bar, after having been expanded about 30 per cent. in cubical dimensions, was found to have a specific gravity of 6.01; a cubic foot of the expanded metal, therefore, weighs $375\frac{1}{2}$ pounds, a difference of $69\frac{1}{4}$ pounds per cubic foot. You will naturally ask, having now examined the two bars: "How was this extraordinary increase in bulk produced while the metal remained in the solid state, retaining its original form, and showing no appearance of any alteration except in size?"

It has been accomplished by alternately heating and cooling the bar many times, and the great increase in size is a very striking corroboration, I think, of the theory advanced in the paper presented to the American Institute of Mining Engineers in 1896 of the mobility of the molecules of cast iron.

In my first experiments in making castings grow in cubical dimensions (which were made prior to the publication of that paper), some test bars were accurately measured and then imbedded in an open sand mold, forming, in fact, the bottom of the mold. The mold was then filled with molten cast iron of about the same composition as the bars and allowed to remain undisturbed until cold. The bars were then removed, placed within the iron yoke and measured by inserting a hardened steel wedge, graduated to read readily to thousandths of an inch between the end of the bar and the yoke. All of the bars had increased in length, and after six repetitions, reversing the position of the bars each time in order to keep them straight, they would no longer fit into the space between the ends of the yoke, showing that they had expanded to the full length of the mold in which the molten metal was poured. In other words, the original shrinkage of the metal had been eliminated. This process was repeated many times, the bars continuing to grow both longer and thicker with each heating.

Tests were made to ascertain the effect upon the strength of the metal, and in all cases there was a marked decrease in strength amounting, in some instances, to 30 per cent.

In the recent experiments, where a much larger growth in cubical dimensions, as in the bars now before you, has been obtained, a different method of heating has been adopted, whereby a record has been secured of the temperatures, and it has been found that there is a certain "critical temperature" which produces the greatest degree of expansion per heat.

All of the bars now shown have been heated in a case-hardening furnace provided with a pyrometer. In order to prevent scaling, or oxidation of the surface, the bars were enclosed in an iron pipe, the ends being stopped with clay. The temperature was at first maintained at about 1200° F. for one hour, the gas was then turned off and the pipe was allowed to cool slowly over night, the bars being removed and measured, when cold, on the following morning. It was found necessary to heat the bars nearly one hundred times in order to obtain an increase in length equivalent to about 1 inch per foot. Then the temperature was increased to 1450° F., when a much greater gain in dimensions occurred, averaging about $\frac{1}{16}$ inch per heat. The bar which has increased $1\frac{11}{16}$ inches in length and $\frac{1}{8}$ inch in cross-section, has been heated twenty-seven times at this critical temperature. It has, however, not yet ceased growing, and I am therefore unable to say what the ultimate expansion will amount to, but the tests will be continued until no further increase can be noted. So far, there is no evidence of disintegration of the metal, and but slight change in structure is visible to the naked eye; the bars are smooth, straight and have sharp corners.

Specimens of the expanded bars having been polished, etched and examined under the microscope, a change in structure then became plainly visible. Mr. Job, the chemist of the Reading railroad, has made some photo-micrographs of these expanded bars, and has kindly sent me a lantern slide containing two views; one of a piece of an untreated bar, the other a piece of the same bar after thirty-five heat-

ings. (See cut No. 1.) He states in his letter that the dark lines radiating in all directions, which appear in the expanded metal, are spaces (cracks) between the crystals of iron, showing that they have been "pushed out in all directions when heated, and have not returned to their original positions when cold," thus proving, I think, that the increase in cubical dimensions of the bar is due to the movement of the molecules, and not to chemical changes or changes of crystalline structure. A careful examination of both photomicrographs shows very similar arrangement of the crystals, the only material difference being that of contiguity of the iron particles.

We will now have thrown upon the screen a photograph (see cut No. 2) showing seven test bars of cast iron, all originally of the same length; two remain for comparison just as they were cast, while five have been expanded in different amounts, from 1 inch up to $1\frac{1}{8}$ inches in length, and from $\frac{3}{8}$ to $\frac{1}{8}$ inch in cross-section.*

The same picture shows a bar of steel cut to 12 inches before treatment, heated and cooled in the same manner sixty-one times; this bar has shortened $\frac{1}{8}$ inch, instead of increasing in length, as may be seen by comparison with the foot rule resting on the bar.

Other bars of steel of different grades, and also of wrought iron, all contracted about $\frac{1}{8}$ inch to the foot under this heat treatment.

The same photograph also shows a section of a bar before treatment, and another of the same bar after having been expanded by repeated heatings and coolings (*Figs. 9 and 10*).

The question naturally arises, have these observations any practical value? It would seem, perhaps, at the first glance that the decrease in strength of cast iron due to the heat treatment would limit the field of usefulness of the expansion process, and even that it may remain a mere scientific

* Since the address was given the experiments have been continued, the bars are all considerably larger than when they were exhibited, and they are still growing in size. [A. E. O.]

curiosity. A little reflection will, however, show that a loss in strength, up to, or even more than, 30 per cent., is entirely negligible in many cases, and already some interesting practical applications have been made of this discovery.

As a proof of this, I now offer for your examination a cast iron pattern of a "pin cam lever" made for a new machine. Some expensive tool-work has been put upon it, as well as upon a duplicate, the pattern having been made in two parts. When this "split pattern" was nearly finished it was found that an error had been made, and both halves were $\frac{1}{4}$ inch too short and $\frac{3}{32}$ inch too narrow. The operator of the case-hardening furnace has skilfully expanded both castings, without serious warping, to the required dimensions.

The picture now about to be thrown upon the screen (see cut No. 2, *Fig. 11*) shows a piston of a small pump which had become worn so that it was too small in diameter for further use; this scrapped casting was rescued happily for experiment, and I was informed before commencing to enlarge the piston that the polished end (having five grooves) was $\frac{6}{1000}$ inch under size. I enclosed the piston in a piece of iron pipe and heated it five times, when, on re-measuring, it was found to have increased $\frac{45}{1000}$ inch in diameter, or more than seven times the amount required to bring it up to the original size. The picture shows the piston just as it was taken from the tube after having been expanded by heat.

The next picture (see cut No. 3) shows a number of small castings, including a turned pulley, a gear-wheel blank, several cast-iron rings and bushings, which have been expanded in the same manner together with companion pieces cut from the same rings before expansion.

The next picture (see cut No. 4) shows a pattern for a casting intended to be used as a protective grating to be laid upon the floor of a core oven over the flue.

The next view (see cut No. 5) shows this same pattern, and in front of it is placed a casting made therefrom which has been in use several months, and has been heated and cooled many times. The casting was simply laid upon the

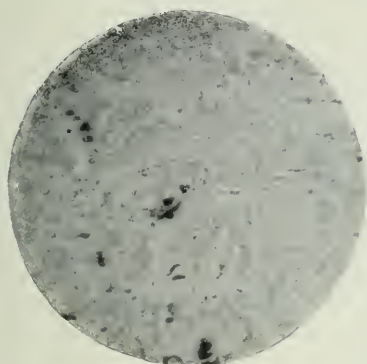


FIG. 1.

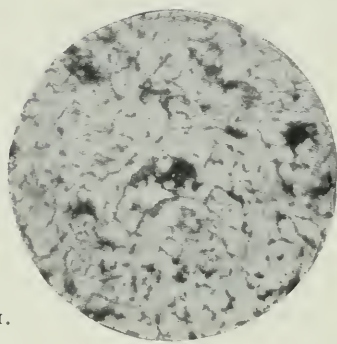
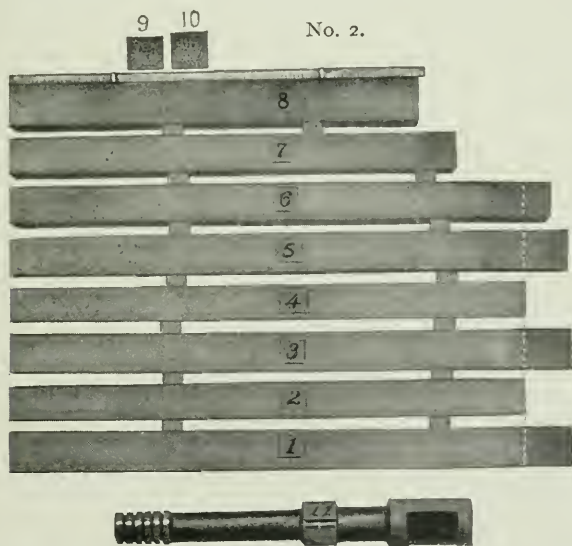


FIG. 2.

Fig. 1. shows appearance of polished section of untreated bar, magnified 50 diameters.

Fig. 2. Polished section of same bar under the same magnification heated 35 times and expanded about 35 per cent. in cubical dimensions.

This bar was cast in a mold $15 \times 1 \times 1$ inches and was cut to 12 inches in length before the heat treatment.



Cast-iron test bars (*Figs. 1, 2, 3, 4, 5, 6, 7*) were all cast of same dimensions, viz.: $14\frac{1}{8} \times 1 \times 1$ inches. Bars 1 and 3 remain unchanged; the others have grown in cubical dimensions, under the heat treatment, from 30 to 40 per cent.

Fig. 7 bar was cut to 12 inches in length before treatment; it is now 13 inches long and $1\frac{1}{8}$ inches cross-section.

Fig. 8 is a steel bar cut 12 inches in length, and it has contracted $\frac{1}{8}$ inch under the same treatment as bar No. 7.

Fig. 9 is a section of bar before treatment.

Fig. 10 is a section of the same bar after expansion by the treatment.

Fig. 11 shows a piston of small pump after having been increased $\frac{4\frac{1}{2}}{1000}$ inch in diameter on polished end before being re ground to size.

The increase in length of the cast-iron bars is shown by the portion between the dotted lines and the right end of bars.

No. 3.

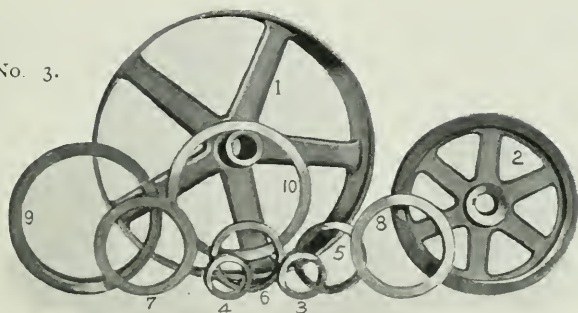


Fig. 1. Cast-iron pulley (turned) $14\frac{3}{4}$ inches outside diameter. Given 4 heatings and expanded $\frac{3}{16}$ inch in diameter.

Fig. 2. Blank gear wheel (turned) $9\frac{3}{8}$ inches in diameter. Given 5 heatings and expanded $\frac{1}{16}$ inch in diameter.

Figs. 3 and 4. Pieces of small bushing $2\frac{5}{8}$ inches in diameter. *Fig. 3* was given 20 heatings and expanded $\frac{5}{16}$ inch in diameter.

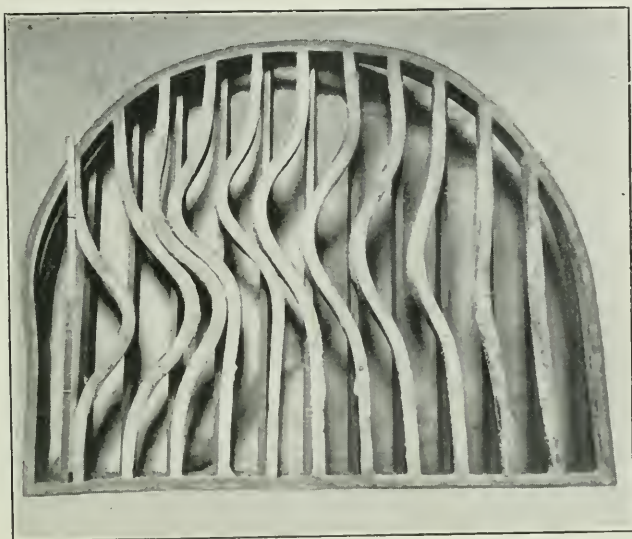
Figs. 5 and 6. Pieces of bushing $3\frac{9}{16}$ inches in diameter. *Fig. 5* was given 15 heatings and expanded $\frac{3}{16}$ inch in diameter.

Figs. 7 and 8. Pieces of bushing 5 inches in diameter. *Fig. 8* was given 16 heatings and expanded $\frac{1}{8}$ inch in diameter.

Figs. 9 and 10. Pieces of large bushing $7\frac{1}{16}$ inch in diameter. *Fig. 9* was given 20 heatings and expanded $\frac{1}{4}$ inch in diameter.



No. 4. Wooden pattern for a protective grating.



No. 5. Wooden pattern, with casting made therefrom, placed in front of it. This casting was laid upon the floor of a core oven, over a flue and about 10 feet above an anthracite fire. The outside frame-work was protected from direct radiation of heat and did not grow in dimensions.

Some of the bars which were highly heated, increased in length from 2 to 3 inches, or over 1 inch to the foot, and in section $\frac{3}{16}$ inch, or in the proportion of $4\frac{1}{2}$ inches per foot.



No. 6. This picture shows an iron yoke in the measuring frame, and an untreated cast-iron test bar (*Fig. 2*) in position for measuring the shrinkage by means of the graduated steel wedge, indicating thousandths of an inch.

The cast-iron bar (*Fig. 1*) was cast in the same mold of same size as the companion bar, and has grown from $14.812 \times 1 \times 1$ inches to $16.5 \times 1.125 \times 1.125$ inches, being an increase of over 40 per cent. in volume, without any increase in weight.

The increase in length is shown by the dotted line ruled across the painted portion of the bar.

floor of the core oven over the flue and not fastened in any way. The bars in the center of the casting were heated by direct radiation from an anthracite fire about 10 feet below the casting, and were, therefore, far removed from the flames. The outside frame-work and the ends of the bars resting on the floor were protected from direct radiation of heat, and consequently remained comparatively cool.

The heated portion of the bars increased in cubical dimensions, just as the test bars have done under similar circumstances, and as the bars could not grow in the direction of their length, being held in place by the non-expanding frame, they were compelled to take the curved forms shown in the picture.

It will be observed that the outside frame of the casting matches the frame-work of the pattern, but some of the bars, having the curved form, have grown longer, the left hand bar for example, from about 22 inches, as originally cast, to $24\frac{1}{2}$ inches in length, and all have also increased greatly in thickness in the parts exposed to the greatest heat. As the foregoing tests have shown that steel bars do not expand under such conditions, it is proposed to have steel castings made from this pattern to replace the distorted iron castings, and it is expected that they will retain their original shape and size indefinitely. As these gratings do not come into contact with the fuel or flames, there will be little tendency to burning or scaling off of the metal. I do not know whether cast-steel grate bars have ever been substituted for cast iron, or whether the scaling would cause their too rapid destruction.

Although my remarks have extended far beyond the time usually allotted for the meetings of the Metallurgical Section, the subject is by no means exhausted, and the facts are presented to you in this tentative form with the hope and expectation that the new observations here given publicity for the first time in their present advanced stage of development will suffice to call forth discussion from experts, and lead, perhaps, to suggestions for new lines of investigation, as well as to other practical applications of the principles.

TABLE NO. I. RESULTS OF EXPERIMENTAL HEATINGS OF CAST-IRON TEST BAR MARKED "A," NO. 1, NOVEMBER 24, 1903.

	Number of Heats.	Length.	Expansion since last Measurement.	Total Expansion.	Rate of Expansion per Heat.
		Inches.	Inches.	Inches.	Inches.
Before Heating		14 $\frac{5}{32}$			
First Measurement	10	15 $\frac{1}{16}$	$\frac{3}{32}$	$\frac{3}{32}$	0'0284
Second Measurement	5	15 $\frac{5}{32}$	$\frac{3}{32}$	$\frac{3}{8}$	0'0187
Third Measurement	2	15 $\frac{9}{32}$	$\frac{1}{8}$	$\frac{1}{2}$	0'062
Fourth Measurement	11	15 $\frac{1}{2}$	$\frac{7}{32}$	$\frac{5}{32}$	0'0199
Fifth Measurement	8	15 $\frac{11}{16}$	$\frac{3}{16}$	$\frac{23}{32}$	0'023
Sixth Measurement	4	15 $\frac{7}{8}$	$\frac{3}{32}$	1 $\frac{3}{32}$	0'046
Seventh Measurement	5	15 $\frac{31}{32}$	$\frac{3}{32}$	1 $\frac{3}{16}$	0'0187
Eighth Measurement	1	16 $\frac{1}{16}$	$\frac{3}{32}$	1 $\frac{9}{32}$	0'0937
Ninth Measurement	4	16 $\frac{5}{32}$	$\frac{3}{32}$	1 $\frac{3}{8}$	0'0234

NOTE.—This bar is one of the regular test bars cast from first of heat of November 24, 1903. Measured 14 $\frac{5}{32}$ -in. long when cast and yielded a total expansion for 50 heats of 1 $\frac{3}{8}$ in. per 15 inches, or at the rate of 0'0275 inches per heat.

TABLE II. RESULTS OF EXPERIMENTAL HEATINGS OF CAST-IRON TEST BAR MARKED "C," NO. 2, NOVEMBER 24, 1903.

	Number of Heats.	Length.	Expansion since last Measurement.	Total Expansion.	Rate of Expansion per Heat.
		Inches.	Inches.	Inches.	Inches.
First Measurement	10	12 $\frac{3}{16}$	$\frac{3}{16}$	$\frac{3}{16}$	0'019
Second Measurement	5	12 $\frac{1}{4}$	$\frac{1}{16}$	$\frac{1}{4}$	0'0125
Third Measurement	2	12 $\frac{3}{8}$	$\frac{1}{8}$	$\frac{3}{8}$	0'062
Fourth Measurement	11	12 $\frac{9}{16}$	$\frac{3}{16}$	$\frac{9}{16}$	0'017
Fifth Measurement	8	12 $\frac{7}{16}$	$\frac{1}{8}$	$\frac{11}{16}$	0'0156
Sixth Measurement	4	12 $\frac{7}{8}$	$\frac{1}{16}$	$\frac{7}{8}$	0.0156
Seventh Measurement	1	12 $\frac{15}{16}$	$\frac{1}{16}$	$\frac{15}{16}$	0'062
Eighth Measurement	8	13	$\frac{1}{16}$	1	0'0077

NOTE.—This bar is a regular test bar with chilled ends cut off, and measured exactly 12 inches long before treatment. Middle of heat of November 24, 1903. Total expansion for forty-nine heats is 1 inch per foot, or at the rate of 0'0204 inches per heat.

TABLE III. RESULTS OF EXPERIMENTAL HEATINGS OF CAST-IRON TEST BAR MARKED "E," NO. 3. NOVEMBER 24, 1903.

	Number of Heats.	Length.	Expansion since last Measurement.	Total Expansion.	Rate of Expansion per Heat.
		Inches.	Inches.	Inches.	Inches.
Before Heating		14 $\frac{1}{16}$			
First Measurement	10	14 $\frac{63}{64}$	$\frac{11}{64}$	$\frac{11}{64}$	0'0171
Second Measurement	5	15 $\frac{1}{16}$	$\frac{5}{64}$	$\frac{1}{4}$	0'0156
Third Measurement	2	15 $\frac{3}{32}$	$\frac{1}{32}$	$\frac{9}{32}$	0'0156
Fourth Measurement	11	15 $\frac{11}{32}$	$\frac{1}{4}$	$\frac{17}{32}$	0'0227
Fifth Measurement	8	15 $\frac{3}{8}$	$\frac{1}{16}$	$\frac{9}{16}$	0'0031
Sixth Measurement	4	15 $\frac{13}{32}$	$\frac{5}{32}$	$\frac{33}{32}$	0'039
Seventh Measurement	5	15 $\frac{5}{8}$	$\frac{3}{32}$	$\frac{13}{16}$	0'0187
Eighth Measurement	1	15 $\frac{3}{4}$	$\frac{1}{8}$	$\frac{15}{16}$	0'125
Ninth Measurement	4	15 $\frac{13}{16}$	$\frac{1}{16}$	1	0'0155

NOTE.—This bar is one of the regular test bars from the last of the heat of November 24, 1903, and measured 14 $\frac{1}{16}$ inches when cast. It yielded a total expansion for fifty heats of 1 inch per 15 inches, or at the rate of '02 per heat.

TABLE IV. RESULTS OF EXPERIMENTAL HEATINGS OF STEEL BARS, SOFT STEEL, TOOL STEEL, CAST STEEL AND WROUGHT IRON.

Material.	Original Length.	Number of Heats.	Contraction.	Number of Additional Heats	Contraction.	Total Heats.	Total Contraction	
							per foot.	per heat.
	In.	In.	In.	In.	In.	In.	In.	In.
Soft Steel Bar Marked No. 2	12	40	$\frac{1}{16}$	23	$\frac{1}{16}$	63	0'125	0'002
Tool Steel Bar Marked No. 3	12	28	—	—	—	28	0'023	0'0008
Wrought Iron Bar No. 4	12	28	—	—	—	28	0'035	0'0012
Piece of Cast Steel Test Bar Tested } for Tensile Strength }	9	10	—	—	—	10	$\frac{1}{32}$ in. per 9 in.	0'0031

In conclusion, I desire to thank you for your close attention, as well as to express my appreciation of the marked interest, indeed, I may say, enthusiasm, that you have shown both in the subject and the illustrations.

DISCUSSION.

DR. C. B. DUDLEY:—I have listened with much interest to the valuable paper of Mr. Outerbridge, and cannot help feeling, in view of the demonstration which he has made, that it is almost ungracious to say that it has been known for several years to car-wheel manufacturers and inspectors that the re-annealing of a car wheel, which means to subject it to the temperature of the annealing pits a second time, gives an increase in tape sizes, sometimes as high as three numbers. The tape size numbers differ from each other by $\frac{1}{8}$ inch. Also, it has likewise been known for quite a while that steel tires which perchance were rolled a bit too large in the tire mill, can be brought back to standard size, so as to be acceptable by putting them in the furnace over night, and allowing them to cool down with the furnace. The cause of these changes I do not think any of us understand as yet. In our studies we had associated the change with the breaking up of the combined carbon, due to heat, which is characteristic of the annealing pits. When car wheels are first cast they show about 1.25 per cent. of combined carbon. After they have been through the annealing pit, this combined carbon is reduced in amount to varying figures, from 0.90 per cent. down to as low in some cases as 0.02 per cent., the average probably being about 0.70 per cent. No careful studies have been made to demonstrate whether this change in combined carbon is always associated with the increase in size of the wheel, and I only make the suggestion as possibly explaining the phenomenon. I do not think any one has so completely studied the subject as Mr. Outerbridge, and I sincerely hope he will continue his studies until he not only arrives at the limit of the growth possible in a test piece, but also until he finds out exactly what the change is and why it takes place. As a matter of suggestion, it may be worth while to put on

record the thought that possibly in some way the change is connected with absorption of oxygen, as there seems to be considerable evidence pointing in the direction that cast iron which has been through the cupola, contains oxygen in some form.

MR. OUTERBRIDGE:—Replying to Dr. Dudley, I would say that, so far from considering his remarks at all ungracious, I think they are not only quite *à propos*, but also corroborative, as far as they go, of my investigations.

I do not claim to have created the peculiar property of cast iron of increasing in bulk under the influence of heat, a property inherent in the metal and existing from all time. I have, however, studied the phenomenon carefully, and have shown that this expansion is enormously greater than has hitherto been suspected. The increase of $\frac{3}{8}$ of an inch in circumference of a 36-inch car wheel, caused by re-annealing, or $\frac{1}{8}$ inch in 3 feet diameter—far less than the original shrinkage of the iron—is, in fact, infinitesimal, compared with the enormous increase in size of bars I have exhibited. Several have increased $\frac{1}{8}$ inch in 1-inch cross-section, as compared with $\frac{1}{8}$ inch in 3 feet in the re-annealed car wheel, and one of which has increased in volume, or cubical dimensions, over 40 per cent. Recently I heard of some cast-iron annealing boxes 15 feet long, which increased 6 inches in length after 80 heatings. This is equal to 1 inch in $2\frac{1}{2}$ feet.

Moreover, a car wheel is under very great compression strains, due to the chilling of the rim, and would naturally tend to enlarge somewhat when re-annealed, owing to the more complete relieving of these compression strains. With regard to the possible influence of combined carbon changed to graphite, I have shown that soft iron bars containing $2\frac{1}{4}$ per cent. silicon and very little combined carbon, expand much more than bars low in silicon and comparatively high in combined carbon under like heat treatment.

With respect to possible "absorption of oxygen," suggested by Dr. Dudley, I may say that in a number of experiments I have filled the tubes containing bars to be heated with powdered charcoal rammed tightly into the interstices and found little or no difference in the results.

I have, however, maintained for many years that iron melted in a cupola absorbs oxygen from the air blast. In a lecture on cast iron published in the *Journal of the Franklin Institute*, March, 1888, I attributed the remarkable effect produced upon the strength of car wheel iron by adding a minute quantity of ferro-manganese (1 pound to 600 pounds) to the fact that "ferro-manganese acts simply as a deoxidizing agent, the manganese seizing any oxygen which has combined with the iron."

This subject has engaged my thought more or less ever since that time, and I have (in a published address) attributed the difference in quality between high-chilling iron for chill rolls melted in a reverberatory furnace, and the same iron melted in a cupola, largely to this cause. Also, in my discussion on cast iron, printed in the *Journal of the Franklin Institute*, November, 1900, the following sentence appears: "Finally, I may say that I am convinced that the presence of iron oxide dissolved in the molten metal is a factor which is commonly overlooked, and is to be feared, especially in strong iron mixtures. The best deoxidizer with which I am familiar is ferro-manganese, which may be added either in the ladle or in the cupola."

The first experiments in expansion of cast-iron bars were conducted during the year 1896, long before the method of re-annealing car wheels was thought of, and even at that time an expansion far greater than that mentioned by Dr. Dudley as having been observed in re-annealed car wheels was noted and recorded.

Early in 1897, the editor of *The Foundry* saw some of the expanded bars in my laboratory, and asked permission to make a note of the curious facts in his journal. As the method of heating those bars was quite different from that which I have here described in detail, and was devised with the special view of eliminating the chance of chemical change of the bars due to oxidation of iron or absorption of sulphur from fuel, it may be well to give the following excerpt from *The Foundry* of April, 1897:

It may be interesting to know that a metallurgical friend of ours, Mr. Outerbridge, of Philadelphia, has been cultivating a very peculiar plant for

nearly a year past, which has been steadily growing in the arid soil of a foundry, and has not yet reached full maturity. The plant we refer to is a cast-iron test bar.

Two bars were cast side by side in one mold from patterns 1 inch square and 15 inches long between the ends of iron yokes. The bars when cold measured the same length, differing only 0.001 inch. When placed within the yoke and carefully measured with a graduated steel wedge, the shrinkage of one bar was found to be 0.184 inch and the other 0.185 inch. (See cut No. 6.)

The shorter bar was then heated by pouring about 10 pounds molten cast iron (of the same composition) over it, the bar forming the bottom of an open mold.

On the following day the bar was again measured, and now showed a shrinkage of only 0.15 inch. The experiment was repeated, and on a second test the steel wedge showed a space of 0.128 inch between the bar and the yoke.

Six times this test was repeated, each time the bar growing longer, and, on the seventh heating, it would no longer fit between the ends of the yoke, showing that the bar had now grown to the full length of the mold in which the iron was cast. In other words, the natural shrinkage of the metal had been entirely eliminated by the gradual increase in length due to successive heatings . . . After fifteen repetitions, the bar increased in less than before at each heating, and though it had not finished growing, curiosity to ascertain the effect upon the strength of the metal prompted the experimenter to break both bars upon the testing machine . . . This curious experiment with the "growing casting," which we have described, is not only interesting as a novel investigation, but it casts new light upon the cause of molecular changes in cast iron when subjected to alternate heating and cooling, and also furnishes valuable information as to the serious effect upon strength.

All of the investigations so far made in expanding cast iron by heat, whether by pouring molten iron over cold bars (as described in *The Foundry* of April, 1897), heating in a closed tube with or without charcoal, heating in a fire without any protection, or by heat radiations from a fire, as in the protective grating, producing practically the same results, tend to convince me that the astonishing change in volume is a molecular and not a chemical one, thus substantiating my original theory of the molecular mobility of cast iron.

As this peculiar property is inherent in the metal, it must have been noticed, in a way, long ago; but so far as I am aware, no careful study has ever been made of the phenomenon, and no previous knowledge has, I believe, existed of the fact that a bar of iron can be increased in bulk more than

40 per cent. over the original volume, while in the solid condition and still retaining its metallic properties.

The decrease in strength appears to bear a relation to the degree of expansion of the test bars.

MR. EDWARD B. HALSEY :—To what heat did you subject the bars in their treatment ?

MR. OUTERBRIDGE :—To almost all temperatures ranging from barely visible redness nearly up to the melting point of the metal. The degree of heat found by tests with a pyrometer inserted in the furnace to be most efficacious, is about 1450° F.; at this temperature we actually obtained an increase in the length of several of these soft iron bars of $\frac{1}{16}$ inch per heat ! The bar which you have examined was increased in size from $14\frac{1}{16} \times 1 \times 1$ inches in twenty-seven heats at 1450° F. to $16\frac{1}{2} \times 1\frac{1}{8} \times 1\frac{1}{8}$ inches, an increase of almost $\frac{1}{16}$ inch per heat and of more than 40 per cent. in volume in the twenty-seven heatings. At 1200° F. the rate of expansion per heat is much less, and, unless the metal be heated to visible redness, the permanent expansion in each heating is so slight that I have not attempted to measure it.

MR. HALSEY :—How were the bars cooled ?

MR. OUTERBRIDGE :—We have tried slow cooling and rapid cooling, even plunging the hot bars sometimes into ice water. The rate of cooling is comparatively unimportant, but I am inclined to believe that slow cooling gives the largest permanent increase per heat for any given degree of heating.

In some cases the bars were cooled in the air; in others they were allowed to remain inclosed in an iron pipe until cold. In still other cases the bars were heated by pouring molten iron over them in an open mold, allowed to cool down with the casting, and then removed when quite cold.

MR. HALSEY :—Does the cast iron decrease in strength in direct proportion as it grows ?

MR. OUTERBRIDGE :—I think it does, but have not made a sufficient number of breaking tests to absolutely prove that point yet.

Correspondence.

ON THE NATURE OF RADIO-ACTIVITY.

To the Committee on Publications :

GENTLEMEN :—The subject of radium and its characteristics has opened many new channels of thought, and it is doubtful if any discovery during the last several centuries can lay claim to greater—or as great—possibilities or more radical and astounding additions to—not to say changes in—the present fundamental science of physics, chemistry and partly also astronomy.

In the course of some experimental work with radium bromide, several thoughts—which to the best of my knowledge are new—occurred to me, and as some of them may be worth recording, I wish to place them on file in the archives of your library as well as before the readers of our *Journal*. They are all, of course, exclusively of a speculative character.

The important role as played by the conic sections in the stellar movements is, of course, well known. We have here the finite line, the ellipse representing the stable condition of any planetary system, while the parabola and hyperbola recall such comets or other stellar bodies that, temporarily at least, are flung away in infinite lines from the central star, to be again accepted into some other system in orbits either finite or infinite, depending upon velocity and direction at their entrance.

In the course of scientific argument it is naturally much safer to argue downwards from a larger scale than to do the reverse, and if we reason that the ionic system of an atom is a system of a continuous motion, each ion possessing its own special orbit, the first question that comes to our mind would be one dealing with the exact character and form of these orbits.

We know the atom of an element like lead, for instance, to possess perfect stability with reference to the movements of its ions, while, on the other hand, we also know that an atom of radium does not possess this stability at all. In an atom of lead, all ions appear to move in finite orbits, while with radium, a large number of them move in lines which—mathematically speaking—appear to be infinite, resulting in the ions being thrown off or away from the central or focal spot of each ionic system.

Does it not seem as if the magnificent consistency of Nature has ordained the infinitely small ion moving within the almost inconceivably small atom to be similar in kind to the vast stellar body moving about in the infinitely great space?

Based upon the above, all matter can be divided, while in the solid state at least, into two kinds, viz. :

(1) Elliptical or finite, possessing no radio-activity.

(2) Parabolic and hyperbolic or infinite, possessing greater or less radio-activity.

The first class means absolute stability, while the second division represents an eventual atomic and ionic destruction.

Nearly all solid chemical elements belong to the first class, while radium, thorium, polonium, etc., seem to have an ionic construction combining the

two divisions into one, certain ions here being continuously forced into infinite orbits, and being subsequently thrown off.

In physics, the question of the actual work of the latent heat has always been rather hazy to the student, the explanation of its necessity to overcome the molecular cohesion being of course true, but not clear and hardly sufficient.

If we accept at least part of this heat as being spent in changing the ionic orbits from finite into infinite, some rather interesting conclusions seem at hand. In changing water into steam, the product becomes expansive, and if one would ask what expansion signifies in view of this new ionic theory, the natural reply would seem to be that it is a state of matter when the ions move in infinite lines, this motion being stopped only by the walls of the surrounding vessel. Hence also it would be fair to assume that all expansive matter is more or less radio-active, depending upon its power of expansion, and again that all elements are therefore radio-active in one state or another. The term "gas" receives from this point of view an entirely new meaning, it being nothing more or less than that particular state of matter when all elliptical ionic orbits have been changed into infinite ones.

It has also occurred to me that the change of a solid element into its "gas" might affect the atoms themselves, causing an atomic movement on similar lines as the one already described for the ions, and that this movement might exist with or without any change in the original ionic orbits, but even in such a case the gases should possess signs of radio-activity, and it would be interesting indeed to test the above suggestions from such a basis.

Yours very truly,

HENRIK V. VON ZERNICOW-LOSS.

PHILADELPHIA, January 25, 1904.

Notes and Comments.

"BANANA" SOLUTION FOR BRONZING.

The following from the *Druggists Circular and Chemical Gazette* will probably be of interest. The so-called "banana solution" (the name being derived from its odor) which is used in applying bronzes of various kinds is usually a mixture of equal parts of amyl acetate, acetone and benzin, with just enough pyroxylin dissolved therein to give it sufficient body. Powdered bronze is put into a bottle containing this mixture and the paint so formed applied with a brush to the article to be bronzed. The thin covering of pyroxylin that is left after the evaporation of the liquid protects the bronze from the air and keeps it from being wiped off by the cleanly housemaid. Tarnished picture frames and tarnished chandeliers to which a gold bronze has been applied from such a solution will look fresh and new for a long time. Copper bronze as well as gold bronze and the various colored bronze powders can be used in the "banana solution" for making very pretty advertising signs for use in the drug store. Lettering and bordering work upon the signs can be done with it. Several stiff very small painter's brushes are needed for such work and they must be either kept in the solution when not in use, or, better still, washed in benzin or acetone immediately after use and put away for future service. It is needless to add that as the "banana solution" is volatile it must be kept well corked.

SPECIAL ALLOYS FOR IMPROVING STEEL.

Of the numerous alloys now in use for improving carbon steel, the following deserve special mention, as all of them are produced in quantity, and, therefore, present commercial products, which may be bought in the present market: (1) ferronickel; (2) ferrochrome; (3) ferrocobalt; 4 ferrochrome nickel; (5) ferrotungsten nickel; (6) ferrosodium; (7) ferroaluminum; (8) ferrotungsten; (9) ferrosilicon; (10) ferrophosphorus; (11) ferromolybdenum; (12) ferrotitanium; (13) ferromanganese; (14) ferrovanadium; (15) ferroboron; (16) ferrouanium; (17) molybdenum nickel; (18) copper silicon. These alloys have become prominent in later years, and are employed in the production of steel, containing a definite percentage of the respective alloying metals. They are added to the molten steel either in lump or powder form, but preferably enclosed in cast-iron tubes, and are thus inserted into the steel bath with perfect assurance of incorporating the whole amount of the charges made. Each of the compound steels thus obtained possesses peculiar and characteristic properties which make it fit for a special purpose, and almost all are known to improve the toughness and elongation of carbon steel, while some of them impart a great hardness and elasticity to that substance. As to the nature of alloys in general, it must be remembered that they are comparable in a degree to "solutions," and are distinguished in chemistry as "undertermined compounds." In many respects they show the average deportment of the metals from which they arise, but, by combining the various metals, alloys of the desired properties can be produced, and on this behavior is based their technical application. To cite a familiar example, gold and silver, which are very soft when in pure condition, may be essentially hardened by alloying them with copper; and copper itself is rendered harder by alloying it with zinc.—Dr. J. Ohly in *Mines and Minerals*.

DIESEL ENGINE INSTALLATION.

What is claimed to be the first American central station equipped throughout with Diesel oil engines has been running—according to the *American Electrician*—since the middle of last July in Jewett City, Conn., a town of 3,000 inhabitants. Steam-power plant could not be considered by the small community, on account of its high first cost, and the authorities decided upon an oil engine installation, after receiving a guarantee from the contractors to the effect that the crude oil consumption per brake horse-power hour of the engines was not to exceed 0.47 pound at full load. The cost of attendance being a comparatively small item, a kilowatt-hour, including wages and supplies, with crude oil at 4.6 cents per gallon delivered, was calculated to come to about 1 cent. The station, 37 feet 8 inches by 30 feet 8 inches over all, contains two 60-kilowatt single-phase 2,200-volt 608 alternators, belt-driven by two B. H. P. triple-cylinder Diesel oil engines, the cylinder bore of which is 10 inches, the common stroke being 15 inches, with cranks displaced by 120° one from the other. A brick chimney, 8 feet high, serves for conducting into the atmosphere the exhaust gases. Underneath the engine room are located two oil storage tanks, the combined capacity of which is 6,500 gallons. The wiring and switchboard arrangement of the station is carried out on usual lines.

ADVANTAGES OF SUPERHEATED STEAM.

The theoretical advantages of superheated steam have been fully realized for some time, but practical difficulties connected with its use in engines of the piston and cylinder type have so far debarred its general use. Notwithstanding all the efforts made to insure high steam economy during fully fifty years, there is at the present time no vessel of importance fitted with superheaters. A series of interesting trials upon a turbine of the De Laval type has recently been conducted at Dresden, and the results are embodied in a contribution to a German technical paper. The tests have continued during the past two years upon a 30-horse-power De Laval turbine in the laboratory with steam of 500° C. superheat. The consumption of steam was accurately determined by condensing all the steam which passed through the turbine. Heat losses were provided against as fully as practicable by jacketing the apparatus. The turbine was arranged to be run at a speed of 20,000 revolutions per minute, reduced by gearing to 2,000 revolutions of the shaft upon which the brake was placed. The machine was operated by steam of a pressure of 6 kilograms per square centimeter (85.33 pounds per square inch), and when exhausting against the pressure of the atmosphere was rated to develop 30 horse-power. An interesting feature of the tests is the use of various nozzles, experiments having been made with diverging and converging nozzles, using bronze and steel as materials. Broadly speaking, the results show a notable economy in steam consumption. The diverging nozzle gives better results than the converging type, and steel was found more advantageous material than bronze.—*Scientific American Supplement*.

ALUMINUM FOR ELECTRICAL CONDUCTORS.

In an instructive article in the *Engineering Magazine*, Alton D. Adams, who is well-known to the readers of this journal as a contributor, shows to what extent aluminum is used in place of copper for the transmission of electricity. Besides being used for the line between Niagara and Buffalo, some twenty miles in length, aluminum has also been adopted for several other transmission lines, among which may be mentioned two in California, which are respectively five and seven times as long as the one at the Falls. It seems that about 1,000 tons of aluminum have been thus employed. Although in conductivity, aluminum is somewhat inferior to copper, and although an increase of 66 per cent. in the size of the wire is therefore needed to do the same work, still the extreme lightness of the metal in the end triumphs. Only half as many pounds of aluminum are required as copper. Consequently, when the price of copper was over 17 cents a pound, aluminum at 35 cents was found just as cheap. Mr. Adams points out several advantages which result from the lower weight of aluminum. The poles can be placed further apart, or lighter arms and pins can be used. The result is greater cheapness in the actual work of constructing the line. It happens that aluminum wires do not so readily work loose on the insulators, on account of the larger sag allowed. The leakage of current from wire to wire through the air with a given voltage or volume is smaller with a large conductor than with a small one. On the other hand, the wire of large cross-section has the disadvantage of giving the wind a good hold when blowing at right angles.

Book Notices.

The International Fire-Prevention Congress, Convened by the Executive of the British Fire-Prevention Committee. Official Record. Published for the British Fire-Prevention Committee by "The Public Health Engineer," 1903.

This publication, containing some forty papers by persons interested in the study of the science of fire prevention, from all parts of the world, as well as stenographic reports of proceedings of the Congress, is a volume of some 200 pages.

For those who had the good fortune to attend the meetings of the Congress, the volume furnishes a means of carefully going over the work of the Congress at leisure. To those who were not present, a complete compilation of the Congress work is therein presented.

The most casual perusal of this volume cannot fail to impress even the layman with the earnestness of the efforts of the British Fire-Prevention Committee in the study of fire prevention. The papers presented and read at the Congress, in English, French and German, were of the greatest interest and cannot fail to mark a decided advance in the art of fire prevention.

The objects of the Congress are clearly and concisely set forth in the report. Unfortunately, the arrangement of the sections prevented a general discussion of the papers presented, and it is, therefore, that the publication before us becomes most valuable, on account of the stenographic reports of the proceedings of the various section meetings.

The record contains, also, a statement of the various Section and Congress resolutions adopted. The reader, be he specially interested in the subject or not, will find much of value in this volume and some matter which has not heretofore been published.

The study of fire prevention, which has been heretofore taken up by a few enthusiasts, both in this country and abroad, should now, with this volume available, become more general to the end that the ravages of that great enemy of mankind, fire, may be more systematically and effectually prevented and controlled.

C. E. H.

The Mechanical Engineer's Reference Book: A handbook of tables, formulas and methods for engineers, students and draughtsmen. By Henry Harrison Suplee, B.Sc., M.E., etc. Philadelphia and London: J. B. Lippincott Company. 1904. (12mo, pp. xii + 787, with appendices) (Price, \$5.50; without index, \$5.)

The author's valuable professional experience as one of the editors of *The Engineering Magazine* has brought him closely in touch with the needs and requirements of the engineer, draughtsman and student, and the reference book he has produced appears to be a thoroughly well-selected, systematically arranged and up-to-date collection of data such as will be useful for reference in the everyday practice of the profession.

The publishers have issued the book in excellent style, and have provided it with an improved thumb-index to facilitate ready reference. W.

Franklin Institute.

[*Proceedings of the Annual Meeting held Wednesday, January 20, 1904.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, January 20, 1904.

President JOHN BIRKINBINE in the chair.

Present, 120 members and visitors.

The annual reports of the Board of Managers, the various Committees and Sections, and of the Trustees of the Elliott-Cresson Fund, were presented and accepted.

The President commented upon the work accomplished during the past year, referring especially to the loyalty displayed by the great body of the members in consenting to an increase of annual dues. He also alluded to the circumstance that during the present year the revenues of the Institute would probably be increased by the income to be derived from the estate of Robert Wright, deceased, who had bequeathed, approximately, \$50,000 to the Institute.

The Secretary reported that the library had lately been enriched by two notable gifts of pamphlets and books, viz.: From Mr. F. A. Genth, Jr., about 2,000 pamphlets on subjects relating to mineralogy, chemistry, etc., from the collection of his deceased father, Prof. F. A. Genth; and from Mrs. Ogden N. Rood, a complete set of "Poggendorff's Annalen der Physik und Chemie" (Poggendorff, Wiedemann, Drude), 1824-1902, with supplementary volumes; "Fortschritte der Physik," 1815-1901, complete; "The American Journal of Science," 1860 to date. This gift is to constitute a memorial of her lately deceased husband, Prof. Ogden N. Rood, of Columbia University.

Mr. E. Stütz read a paper on the process of Dr. Hans Goldschmidt, of Essen, Germany, for producing extremely high temperatures by the interaction of powdered aluminum with metallic oxides, and the application of the reaction in the metallurgical and engineering arts. The speaker illustrated the subject by showing the reduction of nickel oxide, and by welding iron pipe, steel rails, etc., all of which was accomplished in a surprisingly brief space of time. He likewise illustrated numerous engineering applications of "thermite" (as he terms his aluminum and oxide mixture) with the aid of a series of lantern slides.

The meeting passed a vote of thanks to Mr. Stütz for his extremely interesting presentation of the subject. The Goldsmith invention was, on motion, referred to the Committee on Science and the Arts.

The tellers of the annual election, held this day between the hours of 4 and 8 P.M., rendered their report, which was accepted with the thanks of the meeting.

The President thereupon declared the following candidates to have been elected:

<i>For President</i>	(to serve one year)		JOHN BIRKINBINE.
" <i>Vice-President</i>	(" three years)		HENRY HOWSON.
" <i>Secretary</i>	(" one year)		WM. H. WAHL.
" <i>Treasurer</i>	(" ")		SAMUEL SARTAIN.
" <i>Auditor</i>	(" three years)		JOHN GEO. COPE.

For *Managers* (to serve three years).

ROBERT C. H. BROCK,
STEPHEN GREENE,
ALFRED C. HARRISON,
CHAS. A. HEXAMER,

HENRY R. HEYL,
ALEX. KRUMBHAAR,
C. HARTMAN KUHN,
WALTER WOOD.

For the *Committee on Science and the Arts* (to serve three years).

L. L. CHENEY,
JAMES CHRISTIE,
G. H. CLAMER,
J. LOGAN FITTS,
RICHARD W. GILPIN,
WM. O. GRIGGS,

JOHN HAUG,
FRANCIS HEAD,
CHAS. A. HEXAMER,
WALDEMAR LEE,
JACOB Y. McCONNELL,
J. W. RIDPATH,

L. F. RONDINELLA,
ARTHUR J. ROWLAND,
SAMUEL SARTAIN,
FRANK SHUMAN,
F. CARPENTER SMITH,
THOMAS SPENCER,

J. C. TRAUTWINE, JR., URBANE C. WANNER.

(To serve for two years.)

J. M. EMANUEL.

(To serve for one year.)

AMOS P. BROWN,
WM. W. CANBY,

DANIEL EPPELSHEIMER, JR.,
JAMES S. ROGERS,

GEORGE P. SCHOLL.

WM. H. WAHL,
Secretary.

Report of the Board of Managers for the Year 1903; With Appendices Embracing the Annual Report of the Various Committees and Sections.

*Presented at the Annual Meeting of the Institute, held Wednesday,
January 20, 1904.*

To the Members of the Franklin Institute:

A year ago the Board of Managers congratulated the members of the Franklin Institute upon the exhibition of loyalty which it considered was made by adopting the amendment to the by-laws increasing the annual dues. It has now the gratification of renewing congratulations upon the general acceptance of new conditions, and the considerable increase in revenue from membership fees, which appears in the Treasurer's report. It is not to be expected that the incubus resulting from a long series of annual deficits can be removed at once, but with the prospects of an enlarged income the Institute may go forward hopefully in its work.

As this is written we are advised that the bequest of Robert Wright will soon be in part available, and with this addition to our revenue we may anticipate relief in the Institute's finances.

The indebtedness of the Institute (except the usual current bills awaiting audit and payment) is embraced in the mortgage given the Trustees for money advanced to place the library in fire-proof stack-rooms (which mortgage is being paid off in annual installments) and the fund advanced to take care of accumulated floating indebtedness in advance of the increased revenue from dues.

The report of the Committee on Election and Resignation of Members shows a total enrolment of 1,605, of which 145 were added during the year. The apparent loss is attributed by the committee largely to the enforcement of the constitutional provisions for dropping from the roll such members as are in arrears for dues, for but few resignations are traceable to the increase of dues, a fact which emphasizes the continued loyalty of the Institute members.

That the work of the various departments has been prosecuted vigorously during the year will be evident from the various reports appended.

It is a source of regret that divergent interpretations should have been placed upon the provisions establishing one of the valued medals issued *by* the Institute, by the Trustees of this special bequest, and by the Committee on Science and the Arts. The Board, after considering the subject, sustained the position of the committee, and the matter will be adjudicated by an amicable case stated, so as to establish the proper legal procedure in the future. The value placed upon medals awarded by the Franklin Institute is so widely recognized that there must be no question concerning them. The work of the Committee on Science and the Arts has been and is now of great service, and the unselfish labors of its members commands appreciation. If the Franklin Institute had in any way shared in the financial benefits which have resulted to inventors and others from the investigations and awards of the Committee on Science and the Arts, it would to-day be one of the wealthy organizations of the country. But this labor has been, and will continue to be, rendered gratuitously and impartially for the advancement of science and the arts. This committee in 1903 considered in detail sixty-two cases, and finally disposed of forty-seven, granting nineteen medals and four diplomas of merit.

The enrolment of 683 students in the Franklin Institute night-schools, devoted to drawing, mechanical design and naval construction, taxing the available facilities at command as never before, emphasized one feature of the work of the Committee on Instruction, while the large attendance upon the popular lecture courses indicates the commendable activity of the committee in another direction. The large number who take advantage of the Franklin Institute night schools and popular lectures, notwithstanding similar efforts by other organizations more liberally endowed and equipped, evidences the favor in which the Institute is held, and the value placed upon its instruction.

The subjects presented by the Committee on Meetings covered a wide field and attracted considerable attention. It is interesting to note that the problem of smoke abatement, which occupied one monthly meeting, and which has

lately attracted attention from various civic organizations, received its initial presentation at several monthly meetings of the Institute in 1900.

The ten monthly meetings of the Institute were ably supplemented by thirty sessions of the six sections, at which important papers were read and discussed; and the proceedings of monthly meetings and section sessions have supplied interesting material for the pages of the *Journal*, which maintains a wide circulation and which by its exchanges adds materially to the library.

This library, the Institute's most prized asset, with nearly 100,000 technical works, and about 10,000 charts, maps, manuscripts, etc., has crowded all available space, and makes demand for a more commodious building. In fact, all departments are hampered by the location of, and the space available in, our present building. Your Board has not lost sight of this demand, and hopes that it may soon find some way of providing a larger and more centrally located Institute home.

In three years the bi-centennial of Franklin's birth will be celebrated in Philadelphia, and plans for this are now being matured in which the Institute will participate. But what better recognition of the printer philosopher could there be, than the dedication of a substantial building for the Franklin Institute on the 200th anniversary of the birth of Benjamin Franklin?

Numerous disasters, by flood and fire, culminating in the theatre holocaust in Chicago, may well renew interest in the hazard to life and property which accompany our progress as a nation. This subject is in the hands of an Institute Committee, from which a report may be expected, for the Institute should lead in all such discussions.

Death has again taken away an active member of the Board—Theodore D. Rand, Vice-President of the Institute, whose long-continued labors on the Committee on Publication and his services as solicitor were of great value to all. Suitable minute concerning his death was prepared and published in the *Journal*.

By order of the Board.

JOHN BIRKINBINE,
Philadelphia, January 13, 1904.
President.

APPENDICES.

FINANCIAL STATEMENT FOR 1903.

Balance on hand January 1, 1903	\$348 76
Receipts in 1903	30,735 34
	31,084 10
Payments in 1903	30,712 32
Balance on hand January 1, 1904	\$371 78

The Permanent Endowment Funds of the Institute at the end of 1903 amounted to \$89,855.95; an increase in 1903 of \$7,473.

REPORT OF THE COMMITTEE ON LIBRARY FOR THE YEAR 1903.

To the President and Members of the Franklin Institute :

Your COMMITTEE ON THE LIBRARY respectfully submits the following report concerning the matters intrusted to its charge:

The total of additions to the Library during the year 1902 was 4,924, a larger number than that of any year since 1885, and more than the totals of the two previous years of 1901 and 1902, which were 2,025 and 2,013 respectively. The better record of the past year has been made possible through the improved status of the several funded endowments upon the income of which the Library is so largely dependent for its growth.

The accretions of the past year comprised:

- 1,195 bound volumes,
- 543 unbound volumes,
- 3,179 pamphlets and
- 7 charts, of which
- 92 titles were gained through the Bloomfield H. Moore Fund,
- 50 through the M. Carey Lea Fund,
- 159 through the James T. Morris Fund, and
- 1 through the Memorial Library Fund,
- 290 by binding of periodicals,

the remainder representing the gifts from societies, United States and State governments, and individuals who are interested in the Institute's welfare.

Although these funds are in better condition than they have been for some years past, yet the lack of adequate means has compelled the Committee, on several occasions, to refrain from the purchase of opportune offerings, some of which were rare and all of which would have made most valuable additions to the Library. It is the hope that the example afforded by the generous donors of the existing library funds will be emulated by other friends of the Institute.

At this date the library contains:

- 56,265 bound and unbound volumes,
- 41,906 pamphlets,
- 2,863 maps and charts,
- 659 drawings and designs,
- 1,243 photographs,
- 192 newspaper clippings,
- 31 manuscripts, a total of

103,159

The number of periodicals currently received by the Library, including those obtained in exchange for the *Journal* of the Institute, is 533, an increase of 10 over last year. The list comprises all the important technical journals in this country and abroad, together with the periodical publications of government bureaus and of the leading technological institutes and societies throughout the world.

The rebinding of the worn books is still greatly in arrears, and much

remains to be done in this direction. This work, having to be paid for mainly out of the general appropriation allotted to this Committee, is necessarily restricted by other and more imperative requirements, but it has been looked after as fully as these conditions would permit, and as far as possible, wherever actually necessary. An endeavor is now being made to collect through voluntary contributions a sum of money for this purpose, more particularly with the view to binding up recent volumes of British patent specifications.

The number of volumes bound up during the past year, including those of periodicals, as well as some rebinding and repair of worn books, is 387. It might well have been a thousand, with great advantage to the Library.

The Committee found it necessary, in view of the collection of charts and maps, to obtain a chart case, adequate for the proper disposal and preservation of the maps of the U. S. Geological Survey. The cabinet is one of approved construction, with 22 drawers, thus allowing the various maps to be alphabetically arranged by States, instead of being, as hitherto, packed in one drawer, and practically inaccessible. The case is ample for the accommodation of the government maps for the next fifteen years. If funds would permit, another case of somewhat different dimensions would prove extremely useful. Many of the drawings of the John Lenthall collection have never yet been flattened out, and as these are original plans, it is of the utmost importance that they should be permanently preserved.

The South room on the first floor has been provided with shelves, upon which the pamphlet library is now stored. The pamphlets are not as yet finally disposed, as their cataloguing and proper arrangement must wait for the financial means necessary for this work, but they are thus placed out of harm's way, and made at least in some measure accessible. The demand for more space and greater accessibility for our large collections of public documents will soon make it necessary to erect more shelving in the North room, where that portion of our Library is now accommodated.

The application of the rules recently adopted for properly regulating the use of the Library has resulted in an improvement in the class of the day visitors through the exclusion of idle and indifferent persons, and the admission only of members and of others who have need of the Library in the course of their work. The attendance in the evening continues small, excepting when a meeting of the Institute or of one of its sections brings some of the members temporarily to the Library; but this condition must be regarded as inevitable, and as not likely to be much changed so long as the Institute remains located in the heart of the wholesale business section of the city, so little frequented after business hours, and especially after nightfall. When the Library of the Institute is more advantageously located, it will become better known to that large and growing class of the public which is interested in the study and the application of the physical sciences, and its value to the community will be greatly augmented, and with it the influence of the Institute will be correspondingly increased.

LOUIS F. LEVY,

PHILADELPHIA, January 1, 1904.

Chairman Committee on Library.

ANNUAL REPORT OF THE COMMITTEE ON SCIENCE AND
THE ARTS FOR THE YEAR 1903.

HALL OF THE FRANKLIN INSTITUTE.

To the President and Members of the Franklin Institute:

The Committee on Science and the Arts held 13 meetings during the year 1903, at which 62 cases were considered, of which 47 were finally passed upon. These figures, although indicating a fair amount of work, do not adequately represent the full extent of the Committee's activity, since no less than three meetings were, practically, wholly devoted to the consideration of two important (and still pending) cases.

It is proper to mention, also, that, while the number of cases disposed of by reports is somewhat less than in 1902, a satisfactory explanation for this may be found in the fact that a considerable number of pending cases are of more than ordinary interest and importance, and have demanded a large share of time and care in their consideration.

The number of unfinished cases still in the Committee's hands is 42. Each month new subjects are being entered on the Committee's Record Book, and the work in hand and in prospect is ample enough to keep the members fully occupied.

A difference between the Committee and the Trustees of the Elliott Cresson Medal Fund, which made its appearance several years ago, reached an acute stage during the past year by reason of the refusal of the Trustees to honor the request of the Treasurer of the Institute for a medal awarded in a certain case by this Committee acting for the Institute. The Trustees' have taken the ground that they have the right to set aside an award of the Elliott Cresson Medal, where, in their opinion, it is not properly made. In other words, they claim (and in the particular case above-named have exercised) authority to revise and pass judgment on the acts of the Institute, a claim which this Committee cannot admit.

The facts of the case were reported to the Board of Managers, which, with unanimity, supported the Committee. The question at issue is fundamental in its bearing in the relations of the Trustees to the Institute. It will presently be adjudicated in court.

Respectfully yours,

C. E. RONALDSON,

Chairman Committee on Science and the Arts.

PHILADELPHIA, January 1, 1904.

APPENDIX.

DETAILS OF THE COMMITTEE'S WORK IN 1903.

The number of cases pending on December 31, 1902 . . . 57

The number of new cases proposed in 1903 :

(a) By application 20

(b) By reference from the Institute 2

(c) By vote of the Committee 9

(d) Cases reopened 2

Total number of new cases in 1903 33

Total number of cases before Committee in 1903 90

Number of cases considered in 1903	62	
{ of which there were : dismissed, 15.		
{ still pending, 15.		
Number of cases finally disposed of in 1903	50	
Cases pending December 31, 1903	40	
		90
The forty-seven cases completed were determined as follows :		
Award of Elliott Cresson Medal	5	
Award of John Scott Legacy Premium and Medal	11	
Award of Edward Longstreth Medal	3	
Award of the Certificate of Merit	4	
Reports made advisory	12	
Cases dismissed	12	
Total		47

REPORT OF THE COMMITTEE ON MEETINGS FOR THE YEAR 1903.

To the President and Members of the Franklin Institute :

The Committee on Meetings has arranged the programme of the ten stated meetings of the Institute falling in the last calendar year. For all of these meetings, either papers or informal communications were presented on technical subjects of more or less importance, or topics of general public interest were discussed.

The attention of the members is naturally diverted to some extent from the time-honored monthly meeting, by the numerous weekly meetings of the Sections, and it does not consequently occupy to-day the conspicuous place in Institute affairs which it did for many years.

Nevertheless, the participation of members in the stated meetings is well maintained, and it will be the continued effort of the Committee to reserve the meetings as far as possible, for the presentation and discussion of subjects of general interest and importance.

Respectfully yours,

WASHINGTON JONES,

Chairman Committee on Meetings.

PHILADELPHIA, PA., January 1, 1904.

REPORT OF THE COMMITTEE ON PUBLICATIONS FOR THE YEAR 1903.

To the Board of Managers.

GENTLEMEN: The Committee on Publications has nothing of special importance to report concerning its operations during the past year.

As a matter of general interest, however, it appears to be worthy of note by your Committee, that, for a number of years the new material supplied by the various branches of the Institute has sufficed to meet all the requirements of the *Journal*. This state of things is chiefly due to the increased activity

of the Sections, which have supplied an abundance of excellent original matter for publication.

The Institute at large, but especially this Committee, has sustained a severe loss in the death, during the past year, of Mr. Theodore D. Rand, who for a number of years served as its chairman. Mr. Rand devoted to the duties of this position the same conscientious care and attention that characterized all his work, and the Committee desires to place on record its high appreciation of his services.

HARRY W. JAYNE,

Chairman of Committee on Publications.

PHILADELPHIA, PA., January 1, 1904.

REPORT OF THE COMMITTEE ON INSTRUCTION FOR THE YEAR 1903.

To the Board of Managers.

GENTLEMEN: The Committee on Instruction reporting on its work for the year 1903, wishes to call attention to the fact that the popular lecture courses carried on in co-operation with the Central Branch of the Y. M. C. A. were unusually well patronized—a cause for great satisfaction.

The appropriation available for this service, although extremely meagre, nevertheless sufficed for the purpose, for the reason that the gentlemen who served as lecturers gave their time and service gratuitously, for which the thanks of the Committee have cordially been tendered.

The school work conducted under the Committee's general direction has likewise proved highly satisfactory. The attendance of pupils in the several branches has nearly equalled the highest record of any previous year, and the efficiency of the instruction imparted claims the Committee's best acknowledgments.

The following comparative figures of attendance will be of interest :

	1902.	1903.
Drawing School	380	445
School of Machine Design	134	107
School of Naval Architecture	133	85
	647	637

Respectfully submitted,

WM. H. WAHL,

Chairman Committee on Instruction.

ANNUAL REPORT OF THE COMMITTEE ON ELECTION AND RESIGNATION OF MEMBERS FOR THE YEAR 1903.

To the Board of Managers of the Franklin Institute :

The Committee on Election and Resignation of Members respectfully refers to the membership figures appended below for the record of its work for the year 1903. By special and systematic effort the Committee, assisted by a few of the members of the Institute at large, has been able to add 145 names to the membership roll, which goes far toward recovering the numeri-

cal loss caused by the going into effect of the new by-laws, by which it became necessary in October, 1903, to strike from the roll all members whose dues were in arrears for one year or more.

The Committee hopes that its successor to be appointed at the meeting of the Board for organization, will be enabled to continue the work begun the past year and with even better success, and takes this opportunity to urge all members of the Institute to supplement the Committee's endeavors in 1904, by securing new members individually. It seems that it ought to be practicable for each member to obtain at least one new member in a year, and the Committee begs to express the hope and to urgently request that each member will resolve to do this much for the welfare of the Institute. The result of this suggestion when accomplished is easily estimated:

The membership at the close of 1902 was	1,771
New members secured in 1903	145

1,916

Loss by death, resignation and non-payment of dues	311
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Members at close of 1903	1,605
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ALEX. KRUMBHAAR,

Chairman.

REPORT OF THE COMMITTEE ON SECTIONAL ARRANGEMENTS FOR THE YEAR 1903.

To the Members of the Institute:

The Committee on Sectional Arrangements takes pleasure in transmitting herewith the report of the operations of the six Sections of the Institute during the past year. From this it appears that no less than thirty meetings were held. The record of attendance compares most favorably with that of previous years, and a glance at the list of papers which is appended to the report of the Secretaries, will show that, as a whole, they were highly creditable. The most important and generally interesting of these have been published in the *Journal* and speak for themselves.

The Sections are contributing excellent work in maintaining the scientific standard of the Institute.

The plan of holding joint sessions was continued and appears to provide a simple means for maintaining the largest amount of interest and activity in the Section work, which is, year by year, attaining greater prominence.

JAMES CHRISTIE.

Chairman Com. on Sectional Arrangements.

PHILADELPHIA, January 1, 1904.

APPENDIX.

To the Committee on Sectional Arrangements:

The six Sections of the Institute, viz: The Chemical, Electrical, Mining and Metallurgical, Mechanical and Engineering, and Physical Sections, and the Sections of Photography and Microscopy, have been actively engaged during the past year.

In conforming with the new arrangement introduced in 1903, the Sections have continued to meet weekly in joint session. The plan has been criticised as having a tendency to lessen the individual interest in the separate organizations, but while this criticism is undoubtedly true to some extent, the general result has been to secure a more general interest and participation in the meetings, and it so far has justified the opinion of those who advocated the change. Until some other plan shall be devised and put in execution, therefore, the present one will doubtless be found the most satisfactory. There were held during the year 1903, thirty joint sessions, which were devoted to the presentation of papers, communications and discussions on a great variety of technical subjects. Of these, many were of sufficient importance to be deemed suitable for publication in the *Journal*, and all were interesting and profitable.

It must be manifest to all who have given the matter consideration, that the work of the Sections is steadily increasing in importance, and it promises to assume more and greater prominence in the future.

WM. H. WAHL,
for the Secretaries.

PHILADELPHIA, January 1, 1904.

Committee on Science and the Arts.

(Abstract of the proceedings of the stated meeting held Wednesday, January 6, 1904.)

MR. CHAS. E. RONALDSON in the chair.

The following reports were adopted :

(No. 2292.) *Universal Joint*. Waterbury Tool Company, Waterbury, Conn.

ABSTRACT.—This mechanism is covered by U. S. letters-patent, No. 724,068, March 31, 1903, patented to Harvey D. Williams.

The joint is a modification of a pair of Hooke's joints or gimbals, with a suitable mechanism for keeping the two connecting shafts (the driver and the driven) at equal angles with itself (in this case called the equalizer), thus insuring the transmission of motion regularly from one to the other, *i. e.*, the driven shaft having the same angular velocity as the driver at all points of revolution.

The tool is self-contained, and so designed that the included angle between the shafts may be made as small as 120° . That is, assuming one shaft to be fixed, the other shaft may be moved 60° on either side of a line through the first shaft, thus permitting action through a total variation of 120° , and, on account of the equalizing device, there is no departure from the regularity of the motion transmitted.

The Investigating Committee find that while the idea of an intermediate device to keep the two shafts inclined at an equal angle to a central movable place, is not new, the manner in which it is accomplished in the present case is ingenious and meritorious. It appears to have found successful application to printing presses.

The report concludes as follows : Inasmuch as the device is of ingenious design, embodying many points of excellence, such as neatness and compactness, freedom from all projections to catch clothing, having all working parts protected from dust, working in a bath of oil, and exhibiting mechanical skill in its construction, the award of the Edward Longstreth Medal of Merit is made to the Waterbury Tool Company. [*Sub-Committee*, Daniel Eppelsheimer, Jr., Chairman, Edward T. Budd, James Christie.]

(No. 2297.) *Lightning Arresters*. Henry M. Shaw, Newark, N. J.

ABSTRACT.—The invention is protected by U. S. letters-patents No. 724,339, March 31, 1903, granted to applicant.

The report is introduced by a historical review of the state of the act of lightning arresters, and proceeding to the Shaw invention, describes it as follows :

Between two brass castings having circular serrated sides, especially prepared, high-resistance, carbon discs and mica washers are strung, alternating on a fiber rod, the whole being supported on an insulated base. There is a short air-gap between the brass castings and the end carbon discs, the serrations on the castings being along this air-gap. The inventor claims that this last point is important.

The high-resistance quality of the carbon discs employed by applicant gives them a great advantage over plain carbon discs when used for this purpose, as their very high resistance causes them to act as a species of insulator, and also prevents the formation of an arc, while they possess sufficient conductivity to carry without difficulty the static discharges.

The report concludes that, while there is no great novelty in applicant's device, the introduction of high-resistance carbon in the construction of the device constitutes a valuable improvement and a distinct advance in the art. The Edward Longstreth Medal of Merit is awarded to the inventor, Henry M. Shaw. [*Sub-Committee*, Thomas Spencer, Chairman, Wm. McDevitt, Chas. C. Heyl.]

(No. 2299.) *Hydro-Pneumatic Ash Ejector for Steamships*. Horace See, New York.

ABSTRACT.—This invention is covered by several U. S. letters-patent issued to applicant, of which No. 674,021, May 14, 1901, relates to the device in its projected form.

It consists, substantially, of a hopper, which is covered with a lid when the apparatus is not in use as an ash-ejector, or when it is used to discharge water from the ship's bilge. An outlet is provided, leading to a discharge-pipe carried above the ship's water line.

Water under high pressure is supplied by a pump to force the material out of the discharge pipe, a suitable vessel acting as an air-chamber to absorb the shocks of the pump and to regulate the discharge. The cinders mixed with water are discharged overboard. By slightly modifying the method of operation the apparatus is made to serve as a bilge pump.

The report finds that the apparatus is well designed for its intended uses, and concludes with the statement that "no other apparatus that the Committee knows of, will do the work as satisfactorily on ocean-going steamers."

The award of the John Scott Legacy Premium and Medal is recommended. [*Sub-Committee* : H. W. Spangler, Chairman ; H. E. Ehlers, John Haug.]

(No. 2302.) *Concrete Piles*. Frank Shuman, Philadelphia.

ABSTRACT.—This invention, covering the process of making the piles and the tool for the formation of the holes or molds for them, is protected by eight U. S. letters-patent (Nos. 733,286-7-8, 733,335-6-7, July 7, 1903; No. 735,680, August 4, and No. 739,268, September 15, 1903) issued to applicant.

The invention may accordingly be described under two heads:

(1) A tool for the formation of holes in the ground to contain concrete or other plastic materials; said tool consisting of a hollow shank having a head of larger diameter and shaped like a shell used in gunnery, riveted to it. The shell also is open at both ends to admit air below the point while the tool is being withdrawn. During driving, the tool at the apex is closed by a loose plug which drops out when the form is raised, and thus relieves the suction and permitting the removal of the pile-former with a small expenditure of power.

(2) The several devices for the filling of the hole with concrete and for holding it in compact position in loose or permeable soils, such devices consisting of casings or tubing which can be removed readily after the concrete has set; which operation is called here coffer damming.

The report, in considering the prior state of the art, declares that the use of piles or piers, whether of earth, stone, or other minerals, or of vegetable or metal substances, is very old. The previous preparation of the soil by the driving of a preliminary pile—which is subsequently withdrawn to permit the substitution of other material for the final structure—is likewise well known. Hence the merits of this process must consist in securing a better result in less time, or at less cost, or both, and thus bringing it within a range of greater economic possibilities.

The report concedes that applicant's invention possesses decided advantages. The use of the enlarged head permits the piles to be driven much more readily, and to be withdrawn with greater ease and less delay, than by previous methods. In some instances it has been found advantageous to substitute a solid concrete head of larger diameter than the driving rod, instead of the steel shell, and to leave the head in the bottom of the hole, which is filled up with concrete as the tool is withdrawn, the tamping being done by a plunger passing down the well.

The report concludes as follows: In view of the manifest economies and advantages of this method of obtaining substantial foundations in all classes of soils and under adverse conditions of weather, the award to applicant of the John Scott Legacy Premium and Medal is recommended. [*Sub-Committee: Lewis M. Haupt, Chairman; John E. Codman, Louis E. Levy.*]

(No. 2304.) *Investigations on Cast Iron*. Alex. E. Outerbridge, Jr., Philadelphia.

Mr. Outerbridge has extended his investigations of the molecular structure of cast iron, and particularly of the causes of the changes of molecular structure of cast iron under heat treatment, supplementing his earlier discovery of the mobility of the molecules of this metal when submitted to continued vibration, as in tunneling. A detailed account of his later work appears in the *Journal* under the title "Recent Investigations on Cast Iron," to which reference may be made.

The present report is substantially a review of Mr. Outerbridge's work in this field, and dwells at length on the interesting observations respecting the growth of cast iron by repeated annealings, which is fully described in the article just referred to.

The report recognizes the merits of these investigations in the following terms: In view of Mr. Outerbridge's long-continued and thorough investigations into these hitherto unobserved properties of cast iron, the wide recognition his discoveries have received here and abroad, and the immense value of these discoveries to the mechanical world, the Elliott Cresson Medal is awarded to him. [*Sub-Committee*, Thos. B. Conard, Chairman; Robert Job.]

(No. 2295.) *Switch-Operating Device*. Geo. B. Convey, Philadelphia.

An advisory report.

The following reports passed first reading:

(No. 2265.) *Enclosed Arc Lamp*. John Allen Heany, Philadelphia.

(No. 2255.) *Zinc Joint for Rail-bonding*. C. B. Voynew and H. B. Nichols, Philadelphia.

(No. 2305.) *Simplified System of Pitman Phonography*. Francis J. Stein, Philadelphia.

The annual report, giving a summary of the committee's operations for the year 1903, was approved for transmission to the Institute at the annual meeting of January 27, 1904. W.

Sections.

[*Abstracts of stated meetings.*]

MINING AND METALLURGICAL SECTION.—*Stated meeting*, held Thursday, January 7, 1904, 8 o'clock P.M. Mr. G. H. Clamer in the chair. Present, 26 members and visitors.

Mr. A. E. Outerbridge, Jr., of William Sellers & Co., Incorporated, presented a communication giving an account of "Some Recent Investigations on Cast Iron." The speaker's observations have demonstrated that under the influence of repeated annealing between certain limits of temperature, cast iron continuously increases in dimensions, both linear and cubical. The extent of this volume increase, the author had not yet been able to determine. The subject was fully illustrated with specimens and lantern projections.

The paper was discussed by Dr. C. B. Dudley, Mr. Stanley G. Flagg, Mr. Walter Wood, Mr. G. H. Clamer and the author.

The thanks of the meeting were voted to the speaker of the evening. Adjourned.

G. H. CLAMER,

Secretary.

ELECTRICAL SECTION.—*Stated meeting*, held Thursday, January 14, 8 P.M. Mr. Thomas Spencer in the chair. Present, 36 members and visitors.

Dr. W. E. Winship, of the Gould Storage Battery Company, New York, read a communication on "The Application of the Storage Battery to Street Railways." The subject was fully illustrated by means of lantern

slides and drawings. Discussed by Mr. Spencer and the author. After voting the thanks of the meeting to the speaker the session was adjourned.

RICHARD L. BINDER,

Secretary.

SECTION OF PHOTOGRAPHY AND MICROSCOPY.—*Twenty-sixth Stated Meeting*, held Thursday, January 21, 1904, 8 P.M. Dr. Henry Leffmann in the chair. Present, 28 members and visitors.

Dr. Leffman presented a communication on "The Microscopy of Sands."

The speaker referred to the formation of sands by the disintegration of rocks, illustrating the subject by exhibiting a series of thin rock sections with the projecting microscope. He likewise showed projections of sands from various sources which exhibited the differences in size and outlines of grains between river and sea sands.

The subject was discussed by Dr. Wahl and other members of the Section.

Mr. Balderston described in general terms a special adaptation of the projecting microscope devised by Williams, Brown & Earle, designed to fit in between the ordinary lantern and the projecting microscope, and called for this reason the "Mediascope." A number of animal and plant specimens were shown with this attachment, demonstrating its utility for exhibiting comparatively large sections or mounts.

Dr. Leffmann then showed a series of lantern photographs illustrating the high-pressure pipe line lately introduced in the business quarter of Philadelphia for the more effective control of fires; and a series illustrating some interesting engineering features involved in the construction of a railway in the high mountain region of Ecuador. Adjourned.

M. I. WILBERT,

Secretary.

CHEMICAL SECTION.—*Stated Meeting* held Thursday, January 28th, 8 P.M., Dr. E. Goldsmith in the chair. Present 32 members and visitors.

Mr. Martin I. Wilbert presented "A Contribution to the History of the Chemical Industries of the United States," which was illustrated with the aid of a number of lantern photographs. After some discussion of the subject, the thanks of the meeting were voted to the speaker, and the meeting was adjourned.

WM. H. WAHL,

Secretary pro tem.

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Methods of Studying the Effect of Preservatives and other Substances Added to Foods upon Health and Digestion.*

BY DR. H. W. WILEY,
Chief of the Bureau of Chemistry, U. S. Department of Agriculture,
Honorary Member of the Institute.

Food experiments have been conducted from remotest antiquity, but perhaps not with all the scientific accuracy which characterizes the experimental work of modern times. The first recorded food experiment which I have been able to find is described in the Book of Daniel, first chapter, twelfth verse and following.

When Daniel was brought into the royal household of the King of Babylon he was required to eat the food prepared for the King and the court. This the prophet was not willing to do. The chief of the eunuchs, who had taken a great fancy to Daniel, was greatly worried over the situation and informed the recalcitrant Israelite that the King

* A lecture delivered before the Franklin Institute and the Central Branch, Y. M. C. A., in Association Hall, Philadelphia, Friday, October 23, 1903.

would hold him responsible for the poor physical condition which Daniel would doubtless acquire if he failed to eat of the rations prepared for him. Daniel thereupon proposed an experimental test, based on a truly scientific principle, though not attended with that nicety of chemical analysis which to day is the primary condition of such work. He said to the prince of the eunuchs :

Prove thy servants, I beseech thee, ten days, and let them give us pulse to eat, and water to drink. Then let our countenances be looked upon before thee, and the countenance of the children that eat of the portion of the King's meat; and as thou seest, deal with thy servants. So he consented to them in this matter and proved them ten days. And at the end of ten days their countenances appeared fairer and fatter in flesh than all the children which did eat the portion of the King's meat. And in all matters of wisdom and understanding that the King inquired of them, he found them ten times better than all the magicians and astrologers that were in all his realm.

Pulse, we find, is a thick pap or pottage made from meal, presumably the meal of leguminous seeds, such as peas and beans or other similar leguminous plants. At the present day, in the light of modern investigations concerning nutrition, we should be inclined to think that Daniel's ration was a very narrow one, in which the carbohydrate element was decidedly deficient. We are surprised also to learn that on such a diet, which is not regarded as flesh-producing, their countenances became fatter than those of the children who ate of the King's meat. If we should construe the language literally our surprise would not be so great, because "meat" might be particularly lean meat and thus the ration of the King's children be even narrower than that of Daniel and his fellows. But this we are hardly justified in doing, since the term "meat" is evidently used in this sense as a general expression for diet in which, presumably, the carbohydrates bore a prominent part. In one respect at least I have followed pretty closely the line of experiment which Daniel outlined some three thousand years ago, in that I have made the periods of experiment approximately ten days.

In the experiments which I am about to describe, however, instead of pulse and water being the principal items of diet, I have substituted therefor borax and boracic acid. According to newspaper reports, which unfortunately are

not always reliable, the results of my experiments have been very similar to those of Daniel, since it has been proclaimed from one end of the country to the other that the children of "borax," when their countenances were looked upon, were shown to be pinker and fatter than those of the children of pork and beans. So general has this impression become, that one of the distinguished members of the Supreme Court, Justice Brewer, remarked at an after-dinner speech not long ago, that he felt in looking at the fair, rotund faces of the guests that he might be addressing Dr. Wiley's borax boarders.

My purpose in the present address is to outline the nature of the experiments which have been conducted, to call attention to previous experiments of a similar character and note the points of difference and to refer briefly to some of the facts developed in the work. It is not possible at this time to give conclusions relating to the experimental work, because the analytical data, immense in quantity, have not yet been tabulated, averaged, and digested. It would be unwise to put forth any preliminary conclusions until all the data referred to are in shape for a careful study and comparison.

The primary object kept in view in the experiments which we are conducting is to determine by strictly scientific means the effect of preservatives, coloring matters, and other substances added to foods, upon the health of the consumer and upon digestion. We find in literature the most varied opinions of experts, so-called, concerning these matters. Practically every substance which has been used in foods for any purpose, aside from the foods themselves, has been the object of condemnation on the one hand and of praise on the other. Salicylic acid, formaldehyde, borax, sulphurous acid, and benzoic acid, all have their apostles who declare their use in preservative quantities not only harmless, but positively beneficial. On the other hand, we find another set of experts who indiscriminately condemn the use of any preservative or coloring matter whatever. We must be allowed to say that the burden of proof should fall upon the advocates of preservatives and coloring mat-

ters. It is not claimed that these are substances natural to food and their addition must therefore be positively justified. Negative results are condemnatory. If these bodies do no good they have no reason of existence; if they are injurious they should surely be prohibited; if they are beneficial under certain conditions, these conditions should be ascertained and definitely fixed.

In arranging for the experiments, in carrying them out, and in discussing the data, an earnest effort has been made to put aside every theory or personal impression or prejudice connected with the subject. How many times have I been asked: "Are the experiments proving what you expected them to?" I can always answer this question negatively because I had put aside, before beginning the experiments, all expectations. Our object has solely been to ascertain the facts, to establish them if possible beyond cavil, to collate them in what seems a scientific and reasonable manner, and at the end to draw such conclusions as judgment, uninfluenced by prejudice, would approve. Some of the above purposes, it is hoped, will be fully accomplished, because we propose to set forth in detail the manner in which the experiments were conducted, to record all the facts observed just as they occurred, to tabulate the work in the most scientific manner possible, and thus present to competent experts a basis for conclusions. When all this is done it is evident that different conclusions may be derived from the premises by different persons. Whatever our conclusions may be, therefore, we do not claim for them any special virtue, but we do hope so to establish the facts on which they are based that the necessity for a repetition of the work may be relegated to the remote future. The enormous amount of work connected with such experiments and the great expense which necessarily attends them, render it extremely advisable that the work should be thoroughly done, with every possible regard for accuracy, with elimination as far as possible of all sources of disturbance and error and with the establishment on as firm a basis as possible of the recorded observations.

An outline of the method of making the experiments at

this time will be useful in explaining the details of the work, so that when the full data are published later, those who care to look into the matter can understand exactly how they were obtained.

First of all, it is evident that no mere theorizing on the chemical and physical properties of preservatives and coloring matters can be of much value in work of this kind. It is further evident that pharmacological experiments made upon any other animals than man, valuable as they are, will not lead to absolutely definite results. It is well known that the digestive organs of other animals are different from those of man; that the processes of assimilation vary, and that what might be innocuous to such an animal might in other circumstances prove harmful to man, and vice versa. It was therefore concluded that the experiments to be of full value should be made upon the human animal. Fortunately the Department of Agriculture is richly provided with subjects for experiments if only their consent thereto can be obtained.

First of all, therefore, a statement was made of the object of the experiments and this was submitted to a number of young men connected with the Department who were generally college graduates or students engaged in scientific pursuits, but at a low rate of compensation. The only inducement offered to these young men to engage their attention and consent, in addition to the contributions to the progress of science which they would make, was that of free board during the period of the experiment. This, indeed, must be considered as a very small reward for the strenuous life which they were compelled to lead for so long a period. Nevertheless, large numbers of volunteers presented themselves, far in excess of the actual demand. Each applicant was requested to fill out the blank which follows:

Descriptive blank to be filled out by applicants for Hygienic Table.

1. Name and address.
2. Date of birth.
3. Have you had any sickness confining you to your room within a year?
If so, state nature and duration.

4. Are you subject to indigestion? If so, state character and frequency.
5. Do you use coffee, tea, or chocolate with your meals? If so, state at which meals and what beverage you prefer.
6. Do you use tobacco? If so, state in what form, at what times, and quantity.
7. Do you use wine, beer, or other alcoholic beverages?
8. Do you go to stool regularly? At what hours?
9. At what hours do you usually urinate?
10. At what hours do you go to bed? How many hours do you usually sleep?
11. Do you engage in any unusual or violent exercise? If so, what?

The object of the above blank was to get an idea of the personal habits of the applicant and especially to ascertain if he had been lately subject to any serious disease or if he had any hereditary tendency to disease. It was also desirable to know whether the applicant was addicted to the use of tobacco or of alcoholic drinks, and if so, to what extent. I had hoped to be able to secure a sufficient number of applicants who used neither tobacco nor alcohol to make up the corps of cadets, but in this I was unsuccessful. Only a very small percentage of the applicants used neither tobacco nor alcohol. Since alcohol has a positive food value, and it was desirable to eliminate this beverage from the hygienic table, I finally decided to reject the application of all those who used even to a moderate degree alcoholic beverages. I then decided to accept, in so far as it was necessary to make out the number, the applications of those who used tobacco moderately.

It was decided at the beginning that the number at the experimental table should be twelve, divided into two classes of six each. It was evidently impracticable for a young man to continue for seven or eight months in so strenuous a life at so small a compensation. The object of having two classes was that one should be resting while the other was undergoing experimental treatment, thus dividing the time as nearly as possible equally between the two. The number under experiment was subsequently increased to four-

teen for some special purposes. The members of the table having been selected, each one was required to subscribe to the following pledge:

I hereby agree, on my honor, to follow implicitly the rules and regulations governing the hygienic table of the Bureau of Chemistry during the time that I am a member thereof. I agree, during my attendance at the table of observation, to use no other food or drink than that which is provided for me, with the exception of water, and that any water not used at the table will be measured and reported daily as a part of the ration. I further agree that I will continue to be a member of the hygienic table for a period of at least six months, from December 1, 1902, unless prevented by some illness, accident, or unavoidable absence. I agree to continue the regular habits of my life, to indulge in no unusual excess of labor or exercise, and if tobacco be used it shall be used at such times and in such amounts as will be agreed upon between myself and the Chief of the Bureau of Chemistry.

I further agree that I will not hold the Department of Agriculture, nor any person connected therewith, responsible for any illness or accident that may occur during my connection with the hygienic table.

It is evident that in experiments on the human animal it is necessary to rely to a certain extent upon the honor of the person under observation. I have every reason to believe that the members of the hygienic table kept their pledges faithfully. They were young men of high standing, fine character, with no bad habits, and they all took a lively personal interest in the work to which they were devoting themselves. They were required, as is seen by the pledge, to pursue their daily vocations in the usual way. In the case of those who used tobacco, a statement of the quantities used, the character of the tobacco employed, and the times at which it was taken, was made, and they agreed to continue the use in exactly the same way during the entire period.

At the completion of an experimental period, in retiring from the experimental table and passing to the recreation table, the candidate was required to subscribe to the following certificate:

I hereby certify on my honor that during the period beginning ——— and ending ———, I have not partaken of any food or drink (except water reported) other than that furnished at the hygienic table of the Bureau of Chemistry, and that I have accurately recorded all the items of food and drink received at the table.

I further certify that I have not engaged in any excessive or unusual

physical exercise ; that I have followed, in so far as possible, the regular tenor of my daily life in respect of work, exercise and sleep ; that I have observed to the best of my ability and recorded accurately the data relating to weight, temperature and pulse ; and that I have observed faithfully all the regulations connected with the experimental work at the hygienic table.

By thus placing the young men on their honor, by interesting them in the work, and by giving them periods of rest during which they were at liberty to eat moderately at other tables than those set in the Bureau of Chemistry, I secured practically the results which would have been obtained by an absolute control of animals experimented upon both during the periods of eating and the intervening periods.

It may be asked : Why were so many persons selected ? To this I reply that the idiosyncrasy of the human animal is very marked. Experiments made upon a single, or even two individuals, are apt to be very misleading by reason of this idiosyncrasy. I would gladly have extended the experimental work to twenty, thirty, or even fifty, if it had been possible to do the analytical work connected with such a large number. One of the chief differences between the series of experiments under consideration and those previously made has been in this particular. We have experimented with a much greater number of subjects and for a much longer period of time than any of the similar experiments that have heretofore been conducted. We have thus, to this extent, eliminated more completely the errors due to imperfect observation, imperfect control and idiosyncrasy.

The installation of the kitchen was in one of the rooms of the basement of the Bureau of Chemistry, which up to this time has been used as a store-room. The cooking was done on two gas stoves and under the supervision of a cook certified by the Civil Service. The arrangement of the kitchen is shown in the projection which I now throw upon the screen.

The dining-room was one of the rooms set apart for the Road Material Laboratory which, however, could be used for the dining-room without interfering materially with the work carried on there, which was done chiefly at desks around the sides. An illustration of the dining-room is

shown in the projections which are now thrown upon the screen.

The food of each member of the table under observation was weighed or measured; the liquids, such as coffee, milk, tea and water, being measured and calculated to weight from the density of solutions; the solid foods being weighed upon a torsion balance sensitive to a half a gram. The process of weighing is shown in the illustration which is now projected on the screen.

A sample of the food furnished at each meal was taken for analysis, immediately placed in a bottle, stoppered and sealed with paraffin so that no moisture could escape in the necessary interval of time before weighing and subsampling of the sample could be accomplished. Foods which could be used in bulk, such as prepared cereals, etc., were sampled for each lot, thus reducing to some extent the labor of analytical work. The analytical work connected with the experiments was conducted in the food laboratory, and illustrations showing the general character of the work as conducted are now projected upon the screen.

Not only did the analytical work include samples of all the foods used for each meal, but also samples of the urine and feces, which were carefully collected and weighed for each of the members of the table and subjected to analysis. In short, an account was opened with each member of the table, exactly similar in character to a bank account. Each member was charged with all that was given him in food and credited with all which was returned in the excretions. The balance represented the food consumed in the production of heat and energy within the system provided the bodily weight remained constant. Thus an exact and accurate control was kept of each individual which would have made it impossible for him to have violated the rules by taking nourishment in addition to that given him, because all such additional nourishment would have at once been detected by a disturbance of the balance sheet. Each member of the observation table was weighed carefully on a delicate balance each day before dinner, since the determination of the weight of the body and its variations under the experiment

are two of the most important of the data to be obtained. Each member of the table was furnished with blanks, copies of which are projected upon the screen, with which to keep an account of the foods received, the meals at which they were eaten, to enter a record of his weight, of the temperature before and after eating, of the pulse, a record of the beatings of the heart, and all other data connected with the income and outgo of the food. One of these blanks was filled up for each meal and the daily blank filed. From these blanks a statement of the foods consumed was made for the same period of observation.

In the beginning of each experimental period there was first determined how much of the food would be necessary to secure as nearly as possible an even weight of the body. This part of the experiment was called the "fore-period," and lasted, after the manner of Daniel, for about ten days. At the end of this time the daily ration for each member of the table had been determined and this was established as the standard of the ration which we should have during the remaining portion of the experimental period.

The "middle period" represented that portion of the time during which each member of the table ate the rations previously determined, together with the added preservative, borax or boracic acid. This period extended generally from ten to fifteen days.

This was followed by the "after-period," during which the same ration as first determined continued, but the preservative was withdrawn, the object being to restore the body to its normal condition in case it had been disturbed by the use of the preservatives. The after-period as a rule was ten days in length. Thus the whole period under observation varied in each class from 30 to 40 days.

An illustration of the quantity of food eaten by a class under observation for one of the periods is shown in the photograph which is now projected upon the screen. The variations in bodily weight during a period of observation are most conveniently represented graphically. Such a representation covering one of the periods of observation is thrown upon the screen. It bears the graphic lines show-

ing the variations in the weight of each member of the class for a full period, including fore, middle, and after periods. It also shows a combination of these variations in a graphic line based upon the average weight of the members of the class at the time of entering upon a period of observation, with the variations of the average weight by combining into one the individual variations in weight for each day. Thus there is practically eliminated from this graphic line the accidental variations due to idiosyncrasy and error of observation, and the general effect produced in the different parts of a period are shown by the variations in this base line. A balance sheet showing the amount of food charged to each individual during a period of observation, together with the amount with which he is credited, showing the deficiencies or excess, is also thrown upon the screen. (During these projections the particular facts represented by each table and graphic chart were pointed out, without, however, drawing any conclusions of a general nature relating to the whole experiment.)

The above are illustrations of the character of the work which has been accomplished in the study of the effect of preservatives, coloring matters, etc., in so far as the experiments have now extended. When you consider the great amount of time required for each chemical operation, the vast total number of weighings of the food for the control of the work, the equally great mathematical labor of tabulating, computing, averaging, and studying the data for a period covering seven months, you can have some realization of the magnitude of the work which has been undertaken and that part of it which has already been accomplished. The table itself, with its steward, cook, waiter, members, and direction, required the continued services of eighteen persons, who had to work without intermission twelve hours a day, holidays and Sundays included, for the whole period. In the chemical work eight chemists with quite a number of aids were employed during the whole time. The tabulation work, which is not yet completed, has employed five or six expert computers for a period of two or three months and much is yet to be done. The actual cost of the food

consumed during the seven months has varied but little from \$12 per month for each individual. When it is considered that we could not use the scraps and pieces, as is done in ordinary domestic kitchens, but that we had to select the homogeneous parts of the food, this is not an extravagant figure.

CONCLUSIONS DRAWN FROM EXPERIMENTS WITH BORAX IN REGARD TO ITS EFFECT UPON HEALTH AND DIGESTION.

I shall not undertake to give here a résumé of the literature relating to experiments conducted with borax and boric acid, but will content myself by citing the conclusions drawn from some of the more important observations which have been made.

I will begin with the conclusions of Chittenden and Gies, published in the *American Journal of Physiology*, volume 1, 1898. The experiments were conducted upon full-grown dogs, ranging in weight from 17 to 25 pounds. For the details of the experiment, the original paper is cited. The authors draw the following conclusions:

Moderate doses of borax up to 5 grams per day, even when continued for some time, are without influence upon proteid metabolism. Neither do they exert any specific influence upon the general nutritional changes of the body. Under no circumstances, so far as we have been able to ascertain, does borax tend to increase body-weight or to protect the proteid matter of the tissues.

Large doses of borax, 5-10 grams daily, have a direct stimulating effect upon proteid metabolism, as claimed by Gruber; such doses, especially if continued, lead to an increased excretion of nitrogen through the urine, also of sulphuric acid and phosphoric acid.

Boric acid, on the other hand, in doses up to 3 grams per day, is practically without influence upon proteid metabolism and upon the general nutrition of the body.

Borax, when taken in large doses, tends to retard somewhat the assimilation of proteid and fatty foods, increasing noticeably the weight of the feces and their contents of nitrogen and fat. With very large doses, there is a tendency toward diarrhoea and an increased excretion of mucus. Boric acid, on the contrary, in doses up to 3 grams per day, is wholly without influence in these directions.

Borax causes a decrease in the volume of the urine, changes the reaction of the fluid to alkaline, and raises the specific gravity, owing to the rapid elimination of the borax through this channel. Under no circumstances have we observed any diuretic action with either borax or boric acid. The latter agent has little effect on the volume of the urine.

Both borax and boric acid are quickly eliminated from the body through the urine, twenty-four to thirty-six hours being generally sufficient for their complete removal. Rarely are they found in the feces.

Neither borax nor boric acid have any influence upon the putrefactive processes of the intestines as measured by the amount of combined sulphuric acid in the urine, or by Jaffe's indoxyl test. Exceedingly large doses of borax are inactive in this direction, not because the salt is without action upon micro-organisms, but because of its rapid absorption from the intestinal tract.

Borax or boric acid, when given in quantities equal to 1.5-2.0 per cent. of the daily food are liable to produce nausea and vomiting.

Owing to the rapid elimination of both borax and boric acid, no marked cumulative action can result from their daily ingestion in moderate quantities.

At no time in these experiments was there any indication of abnormality in the urine; albumin and sugar were never present.

The next study to which I call your particular attention was made by Dr. Oscar Liebreich, professor in the University of Berlin. The results of the experiments were published as a bulletin in 1899. Dr. Liebreich made an exhaustive study of the literature on the subject up to the time of the conduct of his experiments. These experiments were made upon dogs, rabbits and guinea pigs. In general, the conclusions drawn from the study of the literature and experiments of other authors, and from his own with animals, as set forth by Liebreich, are favorable to the use of borax in small quantities in food products. He summarizes the whole of the matter in the following language:

Now, though severest criticism of medical observations, and experience won from experimental research, justify the conclusion that borax and boric acid are innocuous as preservatives of food, this assertion of course can only be valid within certain limits, a restriction which, however, applies to all victuals and drugs; for we know that medicines, admixtures of food, and even aliments, when taken injudiciously or in excess, cease to be wholesome and suddenly become injurious substances. And, moreover, if harm could be done by borax and boric acid used in the preservation of food, the immense quantities which have already been swallowed would have aroused the attention of medical men, particularly as boracic preservation is openly practised (as may be seen by the butchers' trade journals) and has been unreluctantly accepted by the working classes.

For the preservation of meat, boric acid is used in quantities of $\frac{1}{2}$ to $\frac{3}{4}$ per cent.; of this a great part is lost in watering the meat, particularly in the smoking process, for instance, so that we may estimate $\frac{1}{4}$ per cent. as the maximum amount which reaches the system. Experience has proved that 12 decigrams (1.2 grams) of boric acid or borax, if taken in food daily, even for a considerable time, does not affect health injuriously. Even quantities

twice as large have not been proved injurious, scientific investigation having decisively demonstrated that these doses are far below the limit where deleterious action commences.

Whoever studies the numerous experiments of different investigators with care will end in taking the view of certain authors, a view which has been mentioned above in this discussion, viz., that borax and boric acid, far from being injurious to the human system, are really wholesome substances. But a far greater number of observations will be required before this can be conclusively proved.

Elaborate experiments with borax upon men were conducted by the Imperial Board of Health of Germany, under the supervision of Dr. E. Rost and others, and the results published as Official Documents from the Health Office, Volume xix, Section 1, in 1902. An elaborate review of the literature, with critical comments thereon, is found in this publication. Two men were selected for the experiment, for the details of which the original publication is cited. Dr. Rost's conclusions are distinctly unfavorable to the use of borax as a preservative medium. He discovered local effects in the reddening, inflammation and ulceration of the stomach and the immediately adjacent portions of the digestive canal. He also discovered the production of diarrhoea when doses of borax were not too small. Both with dogs and in the case of five grown men he found that the administration of borax or boric acid to the extent of 3 grams per day produces a diminution in the bodily weight. He found that the complete separation of boric acid from the body was effected very slowly, and that for many days, and with persons suffering from kidney trouble for many weeks, traces of the borax in the system were distinctly detected.

An interesting paper on "The Influence of Boric Acid and Borax upon the General Metabolism of Children," written by Professor Tunnicliffe, of London, and Dr. Rosenheim, was published in the *Journal of Hygiene*, 1901, where full details of the experiments can be found. The authors draw the following conclusions from their work :

Boric Acid.—(1) Small doses, up to 1 gram per diem, continued for some time, exert in healthy or delicate children no influence upon proteid metabolism. The assimilation of the proteid food was improved in one healthy child.

(2) The phosphorus metabolism was unaffected in all cases. The assimilation of phosphorus was in all cases improved. (3) The assimilation of fat was not affected. (4) The body weight increased in all cases. (5) The quantity of feces was not affected. Their nitrogen and phosphorus percentage was slightly decreased. (6) No inhibitory effect upon intestinal putrefaction could be demonstrated.

Borax.—(1) Continued doses of 1.5 grams have no influence in healthy or delicate children upon proteid metabolism. The proteid assimilation was unaffected in healthy children, slightly depressed in the delicate child. (2) The phosphorus metabolism was not affected in healthy or delicate children. The assimilation of phosphorus was improved in all cases, the amount being least marked in the case of the delicate child. (3) The fat assimilation was improved in the case of the others. (4) The body weight was increased in all cases; the increase was most marked in the case of the delicate child. (5) The weight of dry feces and their nitrogen and phosphorus percentage remain unaltered. (6) Borax tended rather to increase intestinal putrefaction.

Boric Acid and Borax.—Both boric acid and borax were quickly eliminated, no cumulative action being therefore probable. (2) Neither boric acid nor borax in any way affected the general health and well-being of the children.

Prof. Victor C. Vaughan and Mr. William H. Veenboer, of the University of Michigan, have conducted interesting experiments with borax as an antiseptic, and reviewed also the work of other investigators on the subject, the results of their investigations being published in *American Medicine* of March 15, 1902. From the results of their work they draw the following conclusions:

(1) The use of borax or boric acid as a preservative in butter and cream in the quantities specified in the recommendations of the English Commission is justified both by practical results and by scientific experimentation.

(2) The dusting of the surfaces of hams and bacon which are to be transported long distances, with borax or boric acid, not exceeding 1.5 per cent. of the weight of the meat, is effective and not objectionable from a sanitary standpoint.

(3) Meat thus dusted with borax or boric acid does not become slimy because the preservative thus used prevents the growth of aerobic, peptonizing microorganisms.

Dr. Liebreich published a second bulletin in 1902, detailing additional experiments with men and animals and dealing particularly with the report of the Imperial Board of Health of Germany before mentioned. This second publication of Dr. Liebreich sought to establish, by experimental data and otherwise, the conclusions given in his first

publication and contained in addition thereto an exhaustive critique of the report of the Imperial Board of Health.

This bulletin of Dr. Liebreich was answered in an exhaustive brochure entitled "Boric Acid as a Preservative," and printed as an official document of the Imperial Chancellor in 1903, in which Dr. Rost summarizes the results of the critical study of Dr. Liebreich's investigations and gives a restatement of the conclusions established by his own work in the following language :

Boric acid is a preservative of small disinfecting power and can protect food from decomposition only by the use of proportionally large quantities. It is deceptive in its character in that it at once both increases the weight of the wares offered for sale and also makes it possible for the flesh with which it is mixed to hold a larger quantity of water than is possible when the flesh is pickled with salt or smoked. Even a still larger addition of this preservative does not betray itself to the person consuming it, either through the taste or through the odor. It has a direct injurious effect in that on the one hand it produces a lower assimilation of meat foods by the human body, and on the other hand it so influences the nutrition of man as to produce a diminution in bodily weight. In this connection it should also be noted that the complete separation of boric acid from the human body requires a very long period. What has been said of boric acid is essentially true also of borax.

Dr. Charles F. Dight, of Minneapolis, has published a pamphlet entitled "A Study of the Effect of Borax and Boric Acid on the Human Body," dated 1902, in which he reviews the work of previous investigators and details his own experiments conducted with pigs. For the details of the work the pamphlet cited can be consulted. As a result of his work he reaches the following conclusions :

Now, the decisive test of anything is in the trial of it. The test of borax and boric acid, as made by various feeding and other experiments followed up by after-death examination, and these supplemented by the therapeutic use of borax and boric acid, give answer with the fullest certainty as to their effect in moderate amounts upon the animal body, and justify the following conclusions:

- (1) That borax exerts no specific action upon the animal body.
- (2) That any effect it exerts is because of and by virtue of its mild alkalinity.
- (3) That the sum total of its effects upon digestion is not harmful.
- (4) That it exerts no ill effect upon the ingredients of the blood.
- (5) That it does not act as an irritant to the tissues generally or locally, nor cause pathological congestions.

- (6) That by its use nutrition is not impaired.
- (7) That it does not increase proteid metabolism.
- (8) That it is not cumulative within the body.
- (9) That borax in moderate amount, 2 grams or more daily, exerts no ill effects upon the adult body.
- (10) That in proportion of 0.5 per cent. it preserves fresh sweet meat from putrefaction for long periods of time, extending into months; while smaller quantities, even to 0.1 per cent. or less, have been shown in practical use to preserve for periods of less duration.
- (11) That putrefaction once begun is not arrested by it nor its further progress checked.
- (12) That it is not a deodorant, removing from or concealing in putrefying meats, the offensive odor.
- (13) That all of this is true of boric acid also, except that any effect it exerts is by virtue of its mild acidity.
- (14) That boric acid may be taken in larger quantities than borax without harm.
- (15) That borax and boric acid, like anything naturally good, may become harmful when taken in excess.

The above citations will be sufficient to show the discrepancy which exists among the results obtained in experimental work with this most interesting body. The extended use of borax and boric acid in food products, especially in meats, milk, and butter, makes them perhaps of greater importance from a hygienic and legal point of view than any of the other preservatives in common use. The great difficulty of controlling experiments of the kind which have been detailed, the idiosyncrasies of the individual on whom they have been tried, and the difference between the action of this preservative on the human digestion and that of the lower animals, is sufficient to account for the greater part of the discrepancies which have been mentioned. Just to what extent the data which we have obtained in our own work will corroborate the views of one of the other schools of experts remains to be seen.

I may close, however, with a few general statements, not conclusions derived from my work but based upon a careful study of the work of others.

Foods can be preserved for a reasonable length of time in most circumstances without resorting to any chemical preservative of any kind. Simple sterilization, which can be applied to most foods, is the most effective and the least

objectionable of all forms of food preservation. There may be occasions of emergency or exigency in which the use of a chemical preservative is rendered imperative. The short period over which such an emergency would extend would not seriously endanger the health of the consumer were he to eat food for a brief period containing any one of the principal preservatives in common use.

It may be, further, a wise policy not to inaugurate absolute prohibition against all preservatives, but it certainly is true that wherever for any reason a preservative must be used the package of food containing it should be clearly marked so that the purchaser and the consumer may be fully informed regarding the matter.

Preservatives which even in small quantities when taken over a long period of time produce deleterious results should not be used in any case where it can be possibly avoided, and they should be permitted only in those cases of exigency and emergency where food cannot be properly preserved by any other means.

National and State legislation should be brought into harmony in matters relating to preservatives and colors so that laws may be uniform, based on sound hygienic and business principles, free of any tendency to prosecute or annoy, and supported by an enlightened public opinion, both on the part of the producers and consumers of food.

I have thus endeavored to set before you the general principles and some of the details of operation of the experiments conducted, and will close by saying that the complete detailed work of the first series of experiments, it is hoped, will soon be ready for publication. Then the second series of experimental work will be begun, following the same general method as that which has been outlined. I believe that you will agree with me that it is only by such an exact, painstaking, and long-continued labor as that which has been outlined that we can reach any safe and lasting conclusions in regard to the particular effects of preservatives, coloring matters, and other substances added to food, upon health and digestion.

THE FRANKLIN INSTITUTE.

Stated Meeting, held Wednesday, October 21, 1903.

The Belmont Filtration Works.

BY JOHN W. HILL.

Chief Engineer Bureau of Filtration, Department of Public Works,
Philadelphia.

(Concluded from p. 110.)

ADMINISTRATION BUILDING.

(Contract No. 42.)

The Administration Building, *Figs. 24 and 25*, is located on the west side of the main court, between Filter No. 6 and the first installation of preliminary filters, and contains on the ground floor a boiler-room, engine- or pump-room, an office and a shelter and locker-room for the men employed about the station.

The second floor over the office will be fitted up for a laboratory for the technical examination of water samples from these and the Roxborough filters, and the basement under the office end of the building will be used as a store-room for tools and supplies.

In the pump-room are placed (under Contract No. 40-A) a set of centrifugal pumps to supply subsided water to the preliminary filter-house to wash the sandbed, and, if desired, also to draw off the water from above the sandbeds of low-level filters, and pump it into the supply pipes of high-level filters (thus avoiding the waste to the sewers of pre-filtered water); a set of duplex direct-acting pumps (furnished under Contract No. 40-B) to take water from the main effluent pipes of the filters, and pump under pressure of 80 to 90 pounds to the sand ejectors and sand washers; and the driving engines, electrical generators and main switchboard (furnished under Contract No. 46) for the electric lighting equipment of the works.

The boiler-room contains four internally-fired marine boilers, each of 200 commercial horse-power capacity. The

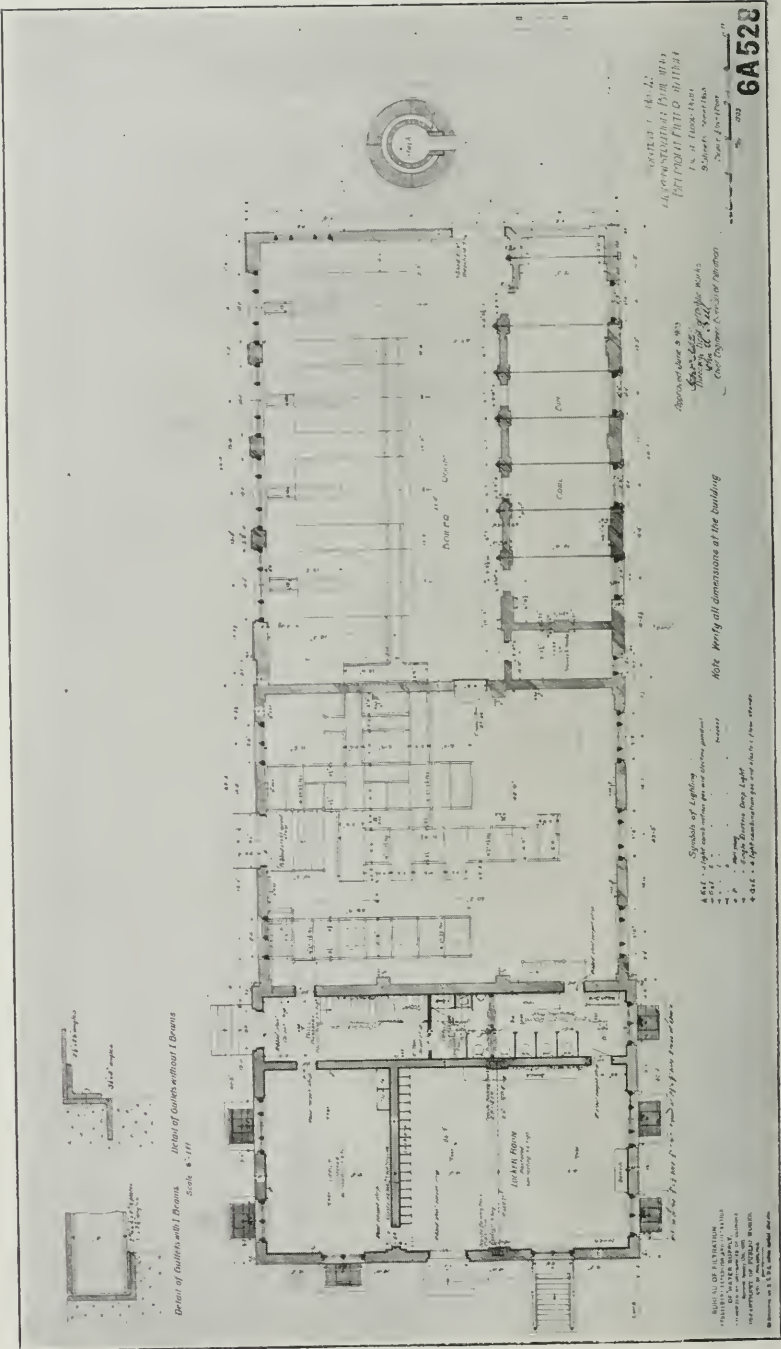


FIG. 24.—Plan of Administration Building and pumping station.

steam power developed will be used partly to pump wash-water to the preliminary filters, partly to pump water to the sand ejectors and washers, and partly to furnish the electric-lighting service for the station, and finally for steam heating of the building.

A "Custodis" chimney, 5 feet 6 inches diameter, 125 feet high, is erected at the south end of the Administration Building.

Fig. 25 shows the east and north elevations of the building. Good lines and substantial construction are the sole objects sought in this detail of the work. Referring to the left end of the front elevation, it will be noticed that the large windows in the rear wall of the boiler-room opposite the boilers, are arranged for complete removal, to permit of taking out or putting in boilers without injury to the brick-work or finish of the room.

The architectural features of the Administration Building are intended to match with the regulator and gate-houses about the filters.

HAND-TRAVELING CRANE.

(Contract No. 65.)

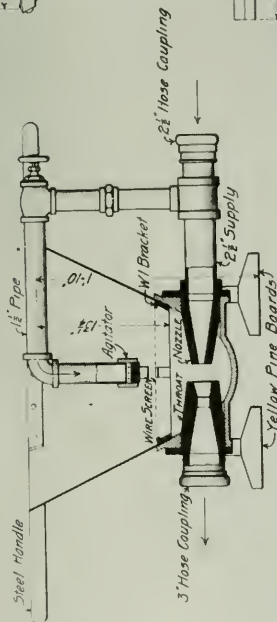
In the pump-room of the Administration Building will be placed a 6-ton hand-traveling crane to facilitate the erection of the pumping and electrical machinery, and for use in making the usual adjustments and repairs to the machinery.

SAND EJECTORS AND WASHERS.

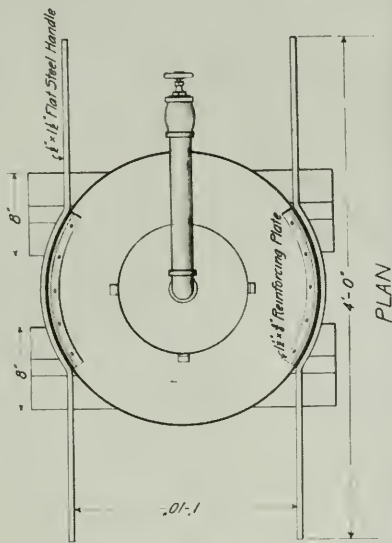
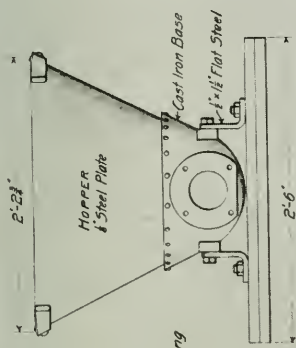
(Contract No. 63—For sand washers only.)

The Belmont station will be equipped with four portable sand ejectors, and eight stationary sand washers, the latter located in the courts convenient to two or more filters.

The sand ejector, as shown in *Fig. 26*, consists of the well-known Korting ejector, mounted in the bottom of a metal hopper. Two lines of waterpipe are connected by ordinary fire hose, with the nozzle and throat extensions, one to supply water under pressure to operate the ejector, and the other to conduct the mixed sand and water from the ejector



ELEVATION



PORTABLE SAND EJECTOR

Scale - 3" = 1 Ft

BUREAU OF FILTRATION
JOHN W. HILL - CHIEF ENGINEER

FIG. 26.—Portable sand ejector.



FIG. 27.—Portable sand ejector in service.

to the washer located in the court outside the filter. The water is brought to the ejector through a $2\frac{1}{2}$ -inch line of hose, and the mixed sand and water taken to the washers through a line of 3-inch hose.

A similar device has been used at the East London Waterworks for several years with excellent success in the rapidity and cost of transporting and washing the sand.

In the construction adopted by the Bureau of Filtration, the entire apparatus, as shown, weighs about 160 pounds, and two men can readily lift and carry the ejector from place to place in the filters convenient to the connections for the supply of water to the apparatus, and for the removal of the mixed discharge to the washers.

In practice the sand is scraped in a heap in each bay of the filter, and the ejector located so as to command at one setting twelve or more heaps. When placed in position the services of two men are required to feed the scraped sand to the ejector.

One ejector will easily throw out from the filter to the washer from 6 to 8 cubic yards of dirty sand per hour. The ejector not only transports the sand to the washer, but, during the trip through the discharge pipe, about one-half of the washing process is accomplished by the time the sand arrives at the washer.

The little ejector, shown in *Fig. 27*, with the services of two men to supply the sand, and a foreman to connect and disconnect the lines of hose to the water supply and discharge pipes, will accomplish in the same length of time the work of over twenty men with wheelbarrows.

The lines of wrought-iron water and discharge pipes are suspended by ordinary pipe hangers from the ventilator openings in the roof vaulting, and by standards resting on the "I" beams of the sand runs, with tees and nipples, as shown in *Fig. 28*, for the attachment of the lines of hose. At Upper Roxborough, and in due time at the other stations, these outlets in the waterpipes have been provided with gate stop-valves to reduce the time required to shift and connect up the ejector as it is moved from place to place in the filter.



FIG. 28.—Portable sand ejector coupled up for use.

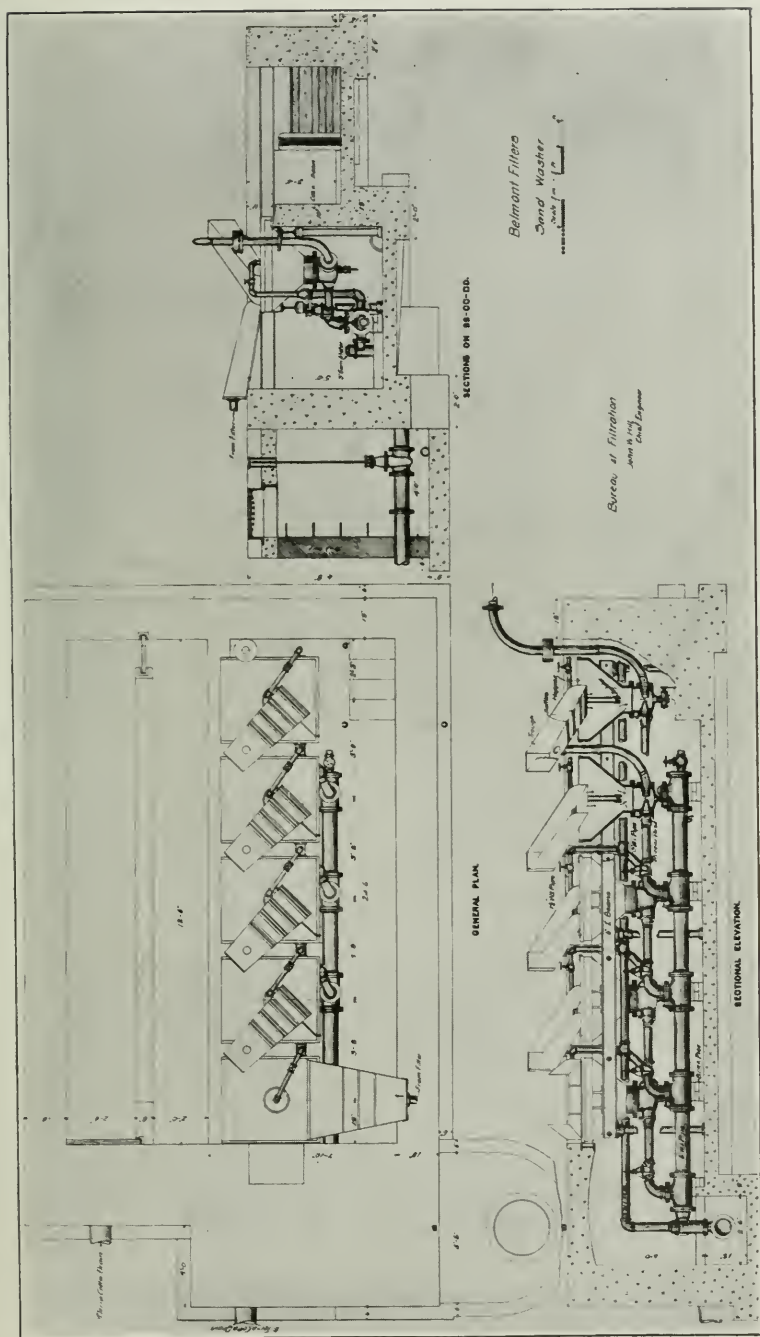


FIG. 29.—Plan of sand washer.

The consumption of water by the ejector is recorded by a 3-inch "Gem" meter placed on the water-supply pipe.

Fig. 29 shows in plan and section the type of sand washer adopted for the Philadelphia filters. This washer consists of a series of hoppers, each about 36 inches square at the top, into which is discharged the partially washed sand from the ejectors, where the ejector of the Korting pattern in the base of the hopper picks up the sand and lifts it into the trough, through which the water and sand flow over low baffles into the next hopper of the series. With the washing which takes place in the discharge pipes of the ejectors, two or three hoppers of the washer will suffice for the proper washing of the sand. From the last hopper of the series, the sand is discharged through a line of wrought iron pipe to the sand piles in the court. The sand-discharge pipe is provided with a swivel joint, which allows the pipe to be swept through a wide arc over the sand piles.

Each hopper at one side at the upper edge is cut down for its full width to form a weir over which the dirty water flows into channels alongside the washer. Baffles are arranged in the channels, which are intended to intercept the sand, while allowing the dirty wash-water to flow away to the sewer.

This washer originated in the Hamburg waterworks, and is there known as the "Schroeder" washer. Each washer is equipped with a "Gem" meter to measure and record the consumption of water.

At Lower Roxborough the sand washers were placed in houses constructed in the courts, but at Upper Roxborough and at Belmont the washers are set in the courts without houses, with the upper edges of the hoppers about flush with the granolithic pavement.

Fig. 30 shows one of the washers set in the court at Upper Roxborough, and the Belmont washers are being constructed in the same way. The open arrangement of the washers gives greater facility in their adjustment and use, and since no manual labor is required at the washer, except to adjust it occasionally and to distribute the washed sand over the piles in the court, no advantage was found

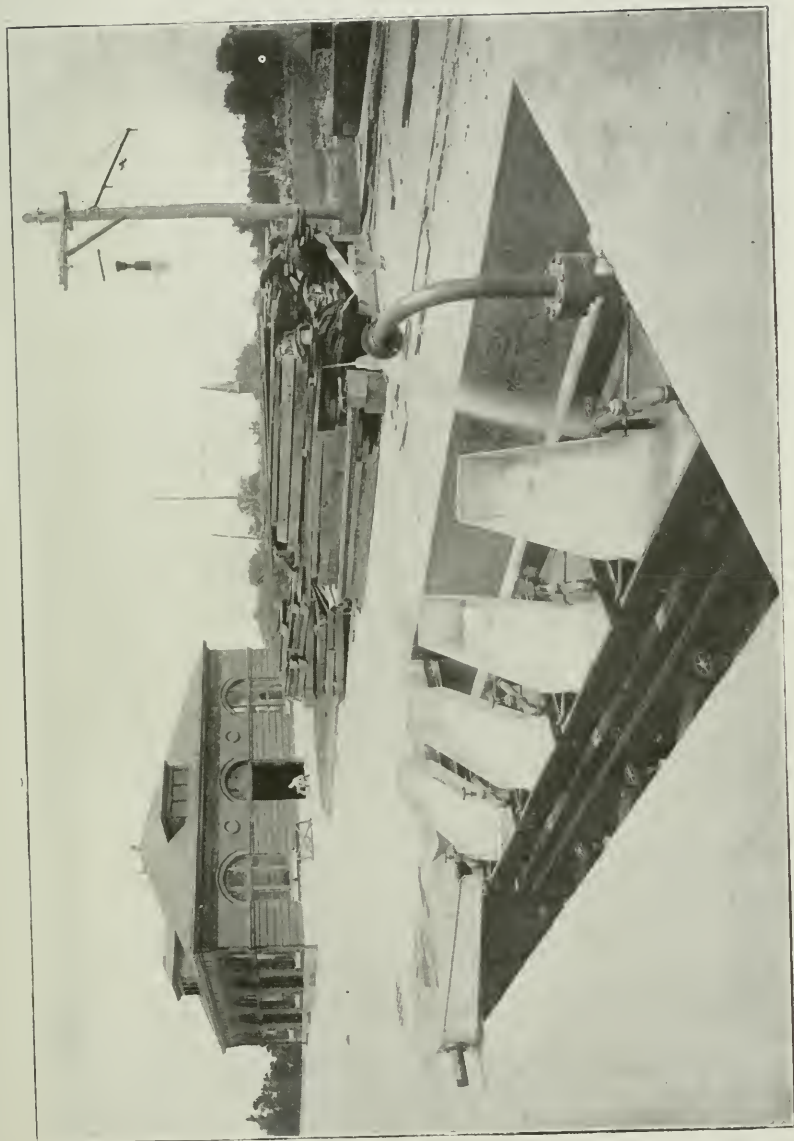


FIG. 30.—Upper Roxborough sand washers.

in the use of houses, such as were put up with the first washers at Lower Roxborough.

In operation the partially washed sand from the ejector working inside the filter is delivered into the galvanized iron trough shown at the left of the washer. Excepting the length of fire hose used to connect the ejector with the waterpipes in the filter, all other lines of pipe to the washer and to the sand pile are made of ordinary wrought-iron steam or gas pipe with flange joints.

Two sand ejectors and one washer combined will transport and wash from twelve to fifteen cubic yards of sand per hour, with an expenditure of 2,400 gallons of water per cubic yard of sand washed, and at a cost ranging from forty-four cents to sixty cents per cubic yard of sand for scraping, transporting and washing. Reduce this to gallons per cubic yard, the cost per million gallons for scraping, transporting and washing sand, after the mechanical appliances are properly adjusted, ranges from sixty-one cents to eighty-four cents per million gallons of water filtered.

ELECTRIC LIGHTING SYSTEM.

(Contract No. 46.)

The electric lighting machinery consists of two direct-current, constant potential, compound-wound six-pole generators (to be furnished by the Fort Wayne Electric Company), each having a capacity at 275 revolutions per minute of $37\frac{1}{2}$ kilowatts at a potential of 225 volts at the switch-board in the engine-house, driven by two horizontal, self-oiling, center crank, direct connected engines (to be furnished by the Watertown Engine Company, Watertown, N. Y.). The engines will work under a steam pressure of 125 pounds per square inch at the throttle.

The current from the generators is carried to the Administration Building, preliminary filters, regulator houses at the filters, into the filters, to the gate houses of the sedimentation and clear-water basins, and to ten enclosed arc lamps placed on iron poles in the courts between the filters.

Each filter is equipped with 148 16-candle-power incan-

descent lamps. The double regulator houses are provided with six lamps, and each single regulator house is provided with four lamps.

The electric lamps in the filters will be used when it becomes necessary to perform some operation connected with the scraping, removal or restoration of the sand during the most severe weather of the winter, or at night time in case of emergency; and to guard against unusual delay, when filters are taken out of service, it was deemed wise to equip each filter with a system of lamps to admit of the work going on during any kind of weather day or night, with the ventilator covers in place, should the service at any time demand it. The Administration Building, preliminary filters, regulator houses of the filters and the gate houses of the reservoir will be illuminated nightly.

CAPACITY AND COST OF THE BELMONT WORKS.

The following table contains the several details and contracts entering into the construction of the Belmont works of filtration, not including real estate or extension of the pipe system for the distribution of the filtered water:

Contract No. 16.	Sedimentation basins	\$670,000 00
	Clear-water basin	260,000 00
	Eighteen plain sand filters	999,000 00
	Contingencies (incurred and assumed) . .	71,000 00
Contract No. 38.	Preliminary filters (estimated)	160,000 00
Contract No. 40-A.	Centrifugal pumping machinery	7,300 00
Contract No. 40-B.	Direct-acting pumping machinery and steam boilers	29,000 00
Contract No. 42.	Administration Building and pumping station	55,000 00
Contract No. 46.	Electric-lighting system	20,000 00
Contract No. 49.	Lateral collectors, underdrains and filter- ing materials	365,000 00
Contract No. 63.	Sand washers	6,800 00
Contract No. 65.	Hand-traveling crane	2,700 00
Contract No. 67.	Preliminary filter house (estimated) . . .	70,000 00
Total cost		<u>\$2,715,800 00</u>

This shows that the cost, based upon an immediate capacity of 40,000,000 gallons of filtered water per day, amounts to \$2,715,800, or \$67,895 per million gallons.

In addition to the items mentioned above entering into the improvement of the works of water supply for West Philadelphia, over \$1,300,000 has been expended for land for the filtration works, new pumping machinery, new engine and boiler house and electric lighting machinery and equipment at the Belmont pumping station; new rising pipes to the sedimentation reservoir, mentioned in this paper, and for extension of the pipe system.

The relative cost of the Belmont works, population considered, is greater than the Roxborough and Torresdale works for the supply of that part of the city lying between the Delaware and Schuylkill Rivers.

Thus the per capita cost of the Belmont improvements is in round numbers \$23.53, while the per capita cost of the combined Roxborough and Torresdale works is \$17.07.

The next step in the enlargement of the Belmont works will be to increase the capacity of the preliminary filters to 65,000,000 gallons per day, instead of 40,000,000 gallons per day as now designed. The total cost then becomes \$2,865,800, or a cost per million gallons capacity of \$44,087.90.

The ultimate capacity of the Belmont works, according to the studies of the Bureau of Filtration, will be 95,000,000 gallons per day of twenty-four hours, requiring an increase of the plain sand filters from eighteen to twenty-six (land for this purpose being available at the south end of the property taken by the city) and an increase of the preliminary filters from 65,000,000 to 95,000,000 gallons per day, making the total ultimate cost \$3,489,800, or a cost per million gallons daily capacity of \$36,734.70.

The present population of West Philadelphia is assumed to be 170,000, and the present consumption about 185 gallons per capita per day. If this rate of consumption continues the present capacity of the works will be sufficient for 216,000 people, or, according to the population curve for West Philadelphia, until 1912, and the capacity of the works when increased to 65,000,000 gallons per day will serve 350,000 people, which population should be reached by 1930, and with an addition of eight plain sand filters and a further increase of 30,000,000 gallons in the preliminary

filters, the works will serve a population of over 500,000 people, which population by the curve will be attained by 1945.

Assuming an allowance of 150 gallons per capita per day, the total population to be supplied and the cost per capita of population is shown in the following table:

For 40,000,000 gallons daily, 266,666 population, \$10.15 cost per capita.

" 65,000,000	"	"	433,333	"	6.65	"	"	"
" 95,000,000	"	"	633,333	"	5.61	"	"	"

The dimensions and all material features of construction of the Belmont filters are substantially the same as for the Upper Roxborough filters; the source of raw water (the Schuylkill River) is alike for both. At this date no filters have been put in operation at Belmont, and it is therefore impossible to present the results of operation. In lieu thereof I am compelled to submit figures showing the performance of the different filters at Upper Roxborough since starting, July 3d of this year, which can safely be accepted as an index of what the Belmont filters will do when put in service.

In the following averages, and highest and lowest bacterial and chemical results, the first two weeks of performance of the filters is omitted. The experience abroad with plain sand filters indicates that from two to three months' time is required before the filters are in fair working service. At Upper Roxborough, however, with one or two exceptions, every filter was delivering an entirely satisfactory water within two weeks of the time it was started.

SCHUYLKILL RIVER AT SHAWMONT.

Week ending 1903.	Bac- teria.	Turbid- ity.	Free Amm.	Alb. Amm.	Ni- trites.	Ni- trates.	Oxy- gen con- sumed.	Chlo- rine.	Iron.
July 4,	26,000	60							
" 11,	25,000	100	'053	'159	'014	'75	2'95	5'2	2'08
" 18,	14,000	25							
" 25,	33,000	170	'089	'215	'010	'79	6'15		
Aug. 1,	16,000	26							
" 8,	42,000	38	'095	'130	'010		2'40	4'5	2'10
" 15,	36,000	30	'064	'102	'010	'71	2'45	4'8	
" 22,	23,000	26	'046	'124	'013	'73	2'15		
" 29,	29,000	20	'041	'118	'012	'65	1'65	5'1	'90

Week ending 1903.	Bac- teria.	Turbid- ity.	Free Amm.	Alb. Amm.	Ni- trites.	Ni- trates.	Oxy- gen con- sumed.	Chlo- rine.	Iron.
Sept. 5,	36,000	34	'101	'161	'011	'77	4'55	5'0	1'88
" 12,	18,000	28	'037	'115	'012	'91	2'15	5'0	1'16
" 19,	18,000	21	'018	'078	'013	'85	1'40	4'1	'88
" 26,	26,000	24	'034	'139	'015	'72	2'60	3'9	'96
Oct. 3,	43,000	12	'014	'103	'011	'71	2'30	6'7	'67
Highest,	43,000	170	'101	'215	'015	'91	6'15	6'7	2'10
Lowest,	14,000	12	'014	'078	'010	'65	1'40	3'9	'67
Average,	27,500	57	'053	'131	'011	'69	2'75	5'0	1'32

APPLIED WATER.

July 4,	18,000	16							
" 11,	760	31	'038	'141	'036	'74	2'50	5'0	1'26
" 18,	325	20	'061	'108	'040	'88	2'00	4'8	'74
" 25,	510	22	'059	'110	'032	'77	1'85		
Aug. 1,	2,300	14	'058		'022	'76	2'65		'65
" 8,	550	13							
" 15,	860	14	'029	'079	'012	'69	1'85	4'8	
" 22,	830	8			'010	'75			
" 29,	540	7	'023	'088	'008	'71	1'45		'30
Sept. 5,	860	14			'010	'73			
" 12,	820	13	'034	'115	'013	'85	2'30	5'1	'48
" 19,	750	11	'043	'099	'013	'87	1'65		
" 26,	780	11	'035	'083	'013	'82	1'50	3'8	
Oct. 3,	1,200	7	'030	'091	'012	'73	1'60		
Highest,	18,000	31	'061	'141	'040	'88	2'65	5'1	1'26
Lowest,	325	7	'023	'079	'008	'69	1'45	3'8	'30
Averages,	2,077	14	'041	'114	'018	'77	1'93	4'7	'68

FILTER NO. 1.

July 4,	680	4	(First week of service.)						
" 11,	670	2	'004	'067	'000	'82	1'55		
" 18,	360	20	'061	'108	'040	'88	2'00	4'8	'74
" 25,	13	1	'004	'070	'001	'94	1'35		
Aug. 1,	19	1	'004	'058	'001	'92	1'60		
" 8,	9	1				'92			
" 15,	6	1	'001	'033	'000	'70	1'05		
" 22,	13	1				'82			
" 29,	8	1	'002	'048	'000	'94	'90		
Sept. 5,	21	1				'76			
" 12,	22	0	'006	'056	'000	'94	1'35		
" 19,	26	0 +			'000	'92	1'00		
" 26,	55	0 +	'002	'051	'000	'88	'80		
Oct. 3,	10	0 +			'000	'78	1'05		
Highest,	360	20	'061	'108	'040	'94	2'00	4'8	'74
Lowest,	6	0	'001	'033	'000	'70	'80	4'8	'74
Average,	46	2	'010	'053	'005	'86	1'23	4'8	'74

FILTER NO. 2.

Week ending 1903	Bac- teria.	Turbid- ity.	Free Amm.	Alb. Amm.	Ni- trites.	Ni- trates.	Oxy- gen con- sumed.	Chlo- rine.	Iron.
July 18, (First week of service)	3,300	5	'023	'073	'002		1'90		
" 25,	63	5	'002	'066	'000	'88	1'45		
Aug. 1,	37	4	'032	'075	'002	'961	'75		
" 8,	13	3				'84			
" 15,	10	2	'002	'071	'000	'701	'10		
" 22,	12	1				'80			
" 29,	8	1	'001	'051	'000	'76	'90		
Sept. 5,	33	1				'76			
" 12,	21	1	'006	'050	'000	'92	1'35		
" 19,	170	0							
" 26,	17	0 +		'047	'000	'88	'90		
Oct. 3,	9	0 +			'000	'76	1'10		
Highest,	170	4	'032	'075	'002	'96	1'75		
Lowest,	8	0	'001	'047	'000	'70	'90		
Average,	33	1 +	'007	'049	'000	'74	1'02		

FILTER NO. 3.

July 4,	360	2	(First week of service.)						
" 11,	240	2	'004	'067	'000	'94	1'75		
" 18,	15	2	'019	'063	'002	1'06	1'35		
" 25,	16	1	'002	'050	'000	'84	1'35		
Aug. 1,	12	1	'006	'063	'000	'92	1'55		
" 8,	9	2				'88			
" 15,	9	1	'001	'046	'000	'76	1'00		
" 22,	5	1				'82			
" 29,	7	1	'002	'046	'000	'76	'90		
Sept. 5,	19	1				'76			
" 12,	30	0 +	'013	'057	'000	'92	1'20		
" 19,	14	0 +		'051	'000	'90	'95		
" 26,	29	0 +	'004	'052	'000	1'04	1'00		
Oct. 3,	14	0			'000	'88	'85		
Highest,	30	2	'019	'063	'002	1'06	1'35		
Lowest,	5	0	'001	'046	'000	'76	'85		
Average,	15	1	'005	'048	'000	'88	1'13		

FILTER NO. 4.

Aug. 8,	1,600	6	(First week of service.)						
" 15,	110	9	'002	'057	'000	'74	1'40		
" 22,	70	7				'80			
" 29,	31	2	'001	'044	'000	'72	1'05		
Sept. 5,	12	2				'80			
" 12,	12	1	'005	'058	'000	'92	1'70		
" 19,	29	1		'056	'000	'88	1'10		
" 26,	32	0 +	'002	'048	'000	'86	'75		

Week ending 1903.	Bac- teria.	Turbid- ity.	Free Amm.	Alb. Amm.	Ni- trites.	Ni- trates.	Oxy- gen con- sumed.	Chlo- rine.	Iron.
Oct. 3,	170	0 +							
Highest,	170	7	'006	'058	'000	'92	1'70		
Lowest,	12	0 +	'001	'044	'000	'72	'75		
Average,	51	2	'002	'052	'000	'83	1'15		

FILTER NO. 5.

July 4,	390	5	(First week of service.)						
" 11,	410	6	'003	'069	'000	'92	1'80		
" 18,	38	4	'009	'063	'000	1'00	1'50		
" 25,	18	3	'004	055	'000	'84	1'40		
Aug. 1,	10	3	'007	'074	'000	'96	1'70		
" 8,	10	2				'88			
" 15,	8	2	'001	'039	'000	'76	1'25		
" 22,	12	1				'80			
" 29,	21	1	'002	'052	'000	'72	'85		
Sept. 5,	18	1				'76			
" 12,	Out of service.								
" 19,	99	1		'049	'002	1'10	1'15		
" 26,	7	0 +	'001	'033	'000	'86	'95		
Oct. 3,	6	0 +			'000	'82	1'10		
Highest,	99	4	'009	'074	'002	1'10	1'70		
Lowest,	6	0 +	'001	'033	'000	'72	'85		
Average,	22	2	'003	'046	'000	'86	1'24		

FILTER NO. 6.

July 4,	1,500	4	(First week of service.)						
" 11,	740	6	'006	'076	'000	'98	1'95		
" 18,	42	5	'005	'067	'000	'98	1'50		
" 25,	21	4	'008	'074	'000	'94	1'40		
Aug. 1,	14	3	'004	'062	'000	'88	1'80		
" 8,	27	2				'86			
" 15,	11	1	'002	'053	'000	'72	1'10		
" 22,	10	1				'86			
" 29,	10	1	'001	'024	'001	'78	'92		
Sept. 5,	59	1							
" 12,	220	1							
" 19,	21	0 +	'001	'035	'000	'84	1'20		
" 26,	6	0 +	'001	'044	'000	'90	'95		
Oct. 3,	7	0 +			'000	'84	1'10		
Highest,	220	5	'008	'076	'001	'98	1'95		
Lowest,	6	0 +	'001	.024	'000	'72	'92		
Average,	37	2	'003	'045	'000	'78	1'25		

FILTER NO. 7.

Week ending 1903.	Bac- teria.	Turbid- ity.	Free Amm.	Alb. Amm.	Ni- trites.	Ni- trates.	Oxy- gen con- sumed.	Chlo- rine.	Iron.
July 4,	160	4	(First week of service.)						
" 11,	550	6	'004	'068	'000	'96	1'75		
" 18,	31	5	'008	'069	'002	'98	1'35		
" 25,	25	3	'002	'058	'000	'80	1'40		
Aug. 1,	17	5	'004	'070	'000	'84	1'75		
" 8,	13	3				'82			
" 15,	8	2	'002	'056	'000	'82	1'35		
" 22,	10	2				'84			
" 29,	180	1							
Sept. 5,	23	1				'76			
" 12,	8	1	.016	'062	'000	'84	1'70		
" 19,	6	1	.002	.041	'000	'82	1'10		
" 26,	9	1	'002	'044	'000	'92	'85		
Oct. 3,	7	1			'000	'82	1'15		
Highest,	180	5	'008	'070	'002	'98	1'75		
Lowest,	6	1	'002	'041	'000	'76	'85		
Average,	28	2	'005	'050	'000	'84	1'33		

FILTER NO. 8.

July 4,	1,000	2	(First week of service.)						
" 11,	2,400	4	'004	'064	'000	'90	1'50		
" 18,	23	2	'014	'066	'000	1'00	1'45		
" 25,	6	1	'004	'045	'000	'80	1'30		
Aug. 1,	7	1	'004	'063	'000	'94	1'40		
" 8,	6	1				'82			
" 15,	7	1	'001	'044	'000	'82	1'10		
" 22,	8	1				'88			
" 29,	4	1							
Sept. 5,	32	1				'92			
" 12,	8	1	.002	'059	'000	'88	1'55		
" 19,	19	0 +							
" 26,	23	0 +		'040	'000	'88	'85		
Oct. 3,	23	0 +			'000	'78	1'00		
Highest,	32	2	'014	'066	'000	1'00	1'55		
Lowest,	4	0 +	'001	'040	'000	'78	'85		
Average,	14	1	'003	'045	'000	'87	1'24		

CLEAR-WATER BASIN.

July 25,	340	3							
Aug. 1,	250	3							
" 8,	34	3							
" 15,	24	3	'002	'044	'000	'72	1'15	4'2	
" 22,	19	2				'80			
" 29,	140	1	'001	'054	'000	'80	1'05		'05
Sept. 5,	20	1							

CLEAR-WATER BASIN.

Week ending 1903.	Bac- teria.	Turbid- ity.	Free Amm.	Alb. Amm.	Ni- trites.	Ni- trates.	Oxy- gen con- sumed.	Chlo. rine.	Iron.
Sept. 12,	41	1	'003	'045	'000	'88	1'65	4'6	'09
" 19,	42	1		'059	'000	'94	'90		
" 26,	24	0 +	'001	'041	'000	'86	1'00	4'7	
Oct. 3,	15	0 +	'002	'043	'000	'80	1'25		
Highest,	140	3	'003	'059	'000	'94	1'65	4'7	'09
Lowest,	15	0 +	'001	'041	'000	'72	'90	4'2	'05
Average,	40	1	'001	'047	'000	'82	1'16	3'3	'07

The sedimentation reservoirs, filters and clear-water basin for the Belmont works were bid for at lump-sum prices for each item, and for purpose of current estimates the unit prices in the following table were adopted:

PRINCIPAL QUANTITIES—BELMONT.

Quantities.		Items.	Unit prices for current estimates.
550,010	Cubic yards	Excavation (unclassified)	\$ 1 00
319,420	"	Embankment and top soil	50
22,150	Square feet	Granolithic pavement	1 50
3,021	Tons	Hub and spigot pipe	41 00
419	"	Hub and spigot specials	94 40
331	"	Flange specials	100 00
261		Stop and check valves (various sizes)	
69,600	Cubic yards	Puddle	2 50
71,150	"	Concrete	6 00
47,800	Square yards	Asphalt lining	1 00
64,250	Pounds	Cast-iron fixtures	02
523,400	"	Steel	03
197,200	Square feet	Expanded metal	15

The contractors for the Belmont Works, Contract No. 16, sedimentation basin, filters and clear-water reservoir, were Messrs. Ryan & Kelley, of Philadelphia, with the Vulcanite Paving Company, of Philadelphia, sub-contractor for the concrete and asphalt work; R. D. Wood & Co., of Philadelphia, sub-contractors for cast-iron waterpipe and special castings; the Ludlow Valve Company, of Troy, N. Y., sub-contractor for stop, check and regulating valves and loss of head gauges; and the American Bridge Company, of Philadelphia, sub-contractor for structural steel-work.

- Contract No. 40-A. Centrifugal Pumping Machinery, R. D. Wood & Co., Philadelphia, contractors.
- Contract No. 40-B. Sand Washer Pumps and Boilers, I. P. Morris Company, Philadelphia, contractor.
- Contract No. 42. Administration Building and Pumping Station, Harry B. Shoemaker & Co., Philadelphia, contractors.
- Contract No. 46. Electric Lighting System, Pennsylvania Equipment Company, Philadelphia, contractor.
- Contract No. 49. Filtering Materials and Underdrains, Daniel J. McNichol, Philadelphia, contractor.
- Contract No. 63. Sand Washers, P. Gormly, Philadelphia, contractor.
- Contract No. 65. Hand-Traveling Crane, Alfred Box & Co., Philadelphia, contractors.

The original engineer field corps in charge of these works was formed with Mr. La Monte Lloyd as first assistant engineer in charge, and Mr. Thomas McE. Vickers, Mr. Charles H. Paul and Mr. Seth M. Van Loan second assistant engineers.

On the 1st of February, 1903, Mr. Lloyd was assigned to office duty in the City Hall, and Mr. Paul was promoted to first assistant engineer in charge of all Belmont contracts, with Mr. J. Lee Allen as second assistant engineer, and Mr. Robley A. Warner as third assistant engineer.

During the progress of the work, Mr. Vickers resigned, and Mr. Van Loan was assigned as first assistant engineer in charge of Contract No. 28—Lardner's Point Pipe Distribution System.

The cost of the engineering and inspection of this work, not including the work performed in the City Hall, in the preparation of plans, estimates, etc., will be, when completed, about 2.08 per cent.

The total time required to complete the work will represent about three years.

The first contract, Contract No. 16, Messrs. Ryan & Kelley, contractors, was started about the 1st of July, 1901, and excepting for unusual causes of delay the entire work should be completed by July, 1904. The average force employed by the contractors during good weather ranged from 800 to 1,000 men.

LENGTHENING THE USEFULNESS OF THE ELECTRIC
GLOW LAMP.

The filament in glow lamps gradually diminishes in diameter in consequence of the slow volatilization of the carbon. According to the *Elektro-technische Rundschau*, a German firm introduces into the glass globe certain chemical compounds with a high boiling point; these, under the influence of the temperature in the lamp bulb, slowly give off vapors containing carbon, which is deposited on the filament, thus making up to a large extent for the loss referred to above, and keeping the resistance and also the brightness of the lamp more uniform throughout its useful life.

FAILURE OF VOLAPUK.

A universal language—one that may be written and understood by all the human family—has been the dream of linguists for a hundred years. Various artificial languages have been invented to answer this purpose, the most notable being the "Esperanto," devised by Professor Zamenhoff, of Moscow, and "Spelin," by Professor Bauer, of Agram, Croatia. Both failed to become popular. As the result of the experiments that have been tried from time to time in this direction, it has become the general opinion that the world will not take up any artificial language until it is fully adopted by the English-speaking nations.

The attempt made to establish Volapuk as a universal language has, I am sorry to say, been a failure. Despite the efforts made by some of the leading linguists to create wide interest in the subject, the experiment did not result as we had hoped it would. The failure was due to the fact that the percentage of those who really need to know several languages besides their own is not yet sufficiently large to insure the success of a universal language.

Volapuk was the most practicable artificial language that had been devised for the purpose. It was invented by the Rev. Johann Martin Schleyer, of Constance, Germany, a celebrated linguist, and he worked out the vocabulary and other details more thoroughly than most of his competitors, so that it was an actual language in working order. It was found to work all right in practice, but not enough people could be found who were willing to devote their time to its mastery to make it a success.

The trouble was that Volapuk was from fifty to a hundred years ahead of its age. I am satisfied that some such universal language, greatly improved upon, perhaps, will one day be adopted by the leading peoples of the earth.

The Volapuk experiment was the most notable ever tried, either here or abroad. Thirteen years ago, when it was at the height of its popularity, no less than 265,000 persons had become familiar with the speaking and writing of Volapuk, and 150 societies had been formed for its propagation. While it was strong in Germany, Austria, Spain, France, Italy, Sweden, and Denmark, in the United States there were only 6,000 students of the new language.

Perhaps the chief reason why Volapuk was not taken up more extensively here was that our young men had not the patience to master a language that was not then in general use. They felt that French or German or Spanish was much more practical, and therefore much more desirable.—*Charles E. Sprague in the Washington Times.*

PHYSICAL SECTION.

*Stated Meeting, held Thursday, October 1, 1903.*A Résumé of Our Knowledge of the Physical Properties
of Current-Bearing Matter.

BY DR. PAUL R. HEYL.

Any present or future hypothesis as to the nature of electricity or of electric conduction in matter must show itself capable of accounting not only for all the changes which a current produces in the matter which conducts it, but also for its failure to produce any alteration, where such is the case. It therefore becomes of interest to see what changes are produced in current-bearing matter, and in what respects the conductor remains unaltered. From this survey it is necessary to omit all reference to current-bearing gases, though much has been learned from the study of the phenomena they present, and, for brevity's sake, to confine ourselves to the probably less familiar cases of conductors and electrolytes.

We shall treat first of the length of a current-bearing conductor. The question whether there is any such change of length unaccompanied by a corresponding change in the cross-section has been considered by several persons. It will be seen at once that to distinguish such an effect in the presence of the general expansion in all directions due to the heating effect of the current is a problem of no little difficulty.

Edlund* heated wires by a current until they had reached a definite elongation, and estimated their temperature by means of their resistance. He found that the calculated temperature was not as great as it should have been to produce the given expansion, and concluded that there was a small elongation due to the current. His method required an accurate knowledge of the thermal coefficients of expan-

* *Pogg. Ann.*, **129**, p. 15, 1866; and *ibid.* **131**, p. 337, 1867.

sion and resistance, and his results were not accepted as conclusive, for the question was soon attacked anew by Streintz.* This experimenter brought his wires to a definite temperature both with and without a current, and compared the relative elongations. To effect this purpose he gave his wires a thin coating of stearin, heated them by a current, and noted the elongation at the instant when the stearin melted. To heat the wire without a current he enclosed it in a glass tube fitted with corks at the ends which served as an air jacket. This tube was contained in a larger tube, and the space between them filled with stearin. A third tube enclosed the whole, and between the outer and middle tubes there circulated a stream of hot water by which the stearin jacket could be kept at its melting point. He made thirteen experiments, and in twelve cases there seemed to be a slight expansion due to the current, while in one case there was an apparent shortening.

Exner† also experimented on this question. He cooled the lower half of his wire by passing it through a glass tube full of water, and heated the cooled and the uncooled halves alternately by a current. He found that the elongation of the cooled half was only 1 or 2 per cent. of that of the uncooled half; but since the stationary water-jacket and the wire it contains must both rise slightly in temperature when a current passes through the wire, this result was not conclusive.

The question was finally settled by Blondlot,‡ who by a most ingenious device succeeded in distinguishing between the thermal expansion and the suggested elongation due to the current. If a conducting sheet elongates, he says, without undergoing any corresponding increase in cross-section, any figure drawn on the surface of such a conductor will be distorted; and, in particular, an angle across which the current runs will suffer an increase in its magnitude. Blondlot used a brass ribbon thoroughly annealed. If such a ribbon

* *Pogg. Ann.*, **150**, p. 368, 1873.

† *Nature*, **13**, p. 452; also Wiedemann, *Lehre von der Electricität*, vol. ii, p. 409, where further references to original papers are given.

‡ *Comptes Rendus*, **87**, p. 206, 1878.

be folded once over and once under, as in *Fig. 1*, any elongation due to the current will increase the angle $A B C$ and cause the ends D, E to separate. This effect may be multiplied to any desired extent by folding the long end E over and D under, repeatedly, until they are again parallel as in *Fig. 2*, giving an arrangement which, when slightly pulled out, may be approximately described as a sort of four-sided screw propeller. If the reader will fold a strip of stiff paper in this manner he will find a series of angles so joined that if each suffers a slight increase the effect is cumulative, and there is a twist in the whole spiral. Blondlot folded his ribbon into 200 such angles, arranged it in a vertical posi-

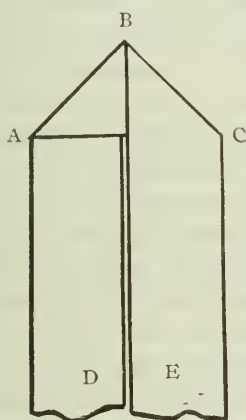


FIG. 1.

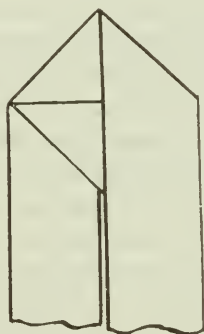


FIG. 2.

tion with one end soldered to a conducting support and the lower end dipping into mercury. A small mirror was affixed to the lower part. By observing from a distance the image of a scale reflected in this mirror the smallest twist could be detected. He used a current density of 370 amperes per square centimeter, and found that when the ribbon was carefully annealed there was no perceptible twist. He says he could have detected an elongation of 0.00025 millimeter. He does not state the length of his ribbon, but from the fact that he was able to fold it 200 times it must have been in the neighborhood of a meter long. Imperfect annealing or poor soldering of the upper

contact produced a slow twist in the wire which disappeared slowly when the current was stopped. This was evidently due to unequal heating, and serves to show the extreme delicacy of the method. The existence of an elongation or contraction unaccompanied by a proportional change in cross-section thus seems to be definitely disproved. The question of a change in volume by expansion in all directions, or (what amounts to the same thing) a change in the thermal coefficient of expansion due to the current, is left still open.

We shall next consider the elasticity of a current-bearing conductor. Wertheim* tested this in two ways, by Young's Modulus, and by the note produced by a vibrating wire, and found apparently a small diminution in the elasticity. He seems to have taken no precautions to eliminate or allow for the heating effect of the current other than remarking that the fall in pitch in the case of the vibrating wire could not have been caused by the heating, else the note would have risen slowly when the current was stopped, whereas it rose rapidly. A sample result on a vibrating wire is this: a copper wire, diameter 0.59 millimeter, gave 1,058 vibrations per second without a current, and 1,041 with a current of 7.8 units. We cannot identify this current strength to-day, as he chose for his unit that strength of current which gave 10° deflection on his galvanometer, of which instrument no description is given, but which, in the figures that accompany the original paper, looks like an instrument of the Melloni astatic type. The fall in pitch mentioned above is very small, about $\frac{1}{8}$ of a whole tone. Later investigations have shown that Wertheim's results are undoubtedly untrustworthy.

Streintz† experimented on the modulus of torsion, using stearin-covered wires, as in his length experiments. He found the time of vibration to be the same, whether the wire was heated with or without a current. He supposed at that time, from his length experiments, that allowance must be

* *Ann. de Chim. et de Phys.*, 1844 [3] ; **12**, p. 610.

† *Progg. Ann.*, **150**, p. 368, 1873.

made for the current elongation, which would show a small change in the modulus; but as it is now known that no such elongation exists, his results are really negative.

Mary C. Noyes* investigated Young's Modulus. At first she thought that there was an irregular effect, varying with the history of the wire, such as the number of times it had been heated or had carried a current. In her second paper she adopted the method of measuring the temperature of the wire by its elongation. Apparently unaware of Blondlot's results, she remarks that some experimenters have found small changes in length due to the current, but that these were negligible. Measuring on this basis, which is probably entirely accurate, she found no perceptible effect on Young's Modulus other than that due to the accompanying heating effect of the current.

The next property to be considered is cohesion. Peltier† sent currents through wires of copper and iron for from 4 to 19½ days, afterwards breaking them while no current was passing. It appeared as if copper was weakened by this treatment and iron strengthened. There are several objections to be urged in this connection, chiefly the long continued thermal effect, and the fact that pieces of wire cut from the same spool may vary several per cent. in tensile strength. The latter difficulty can be eliminated only by a large number of systematic observations.

Wertheim‡ broke wires while the current was passing, and found that gold was apparently weakened about 40 per cent. He seems to have broken one such wire with the current and one without it. In a few experiments on iron and steel he found changes sometimes one way and sometimes the other, of the order of 2 to 10 per cent. His treatment of the subject is not sufficiently elaborate, and he says himself that he is unable to distinguish between the sought effect and the accompanying thermal effect.

The present writer has some experiments on this ques-

* *Physical Review*, **2**, p. 277, 1895, and **3**, p. 432, 1896.

† *Comptes Rendus*, **20**, p. 62, 1845.

‡ *Ann. de Chim. et de Phys.*, 1844 [3], **12**, p. 610.

tion in progress. They are not yet ready for publication; but, so far as he has yet gone, his results are negative.

It has always been assumed, without any definite experimental evidence, that the weight of a current-bearing conductor is unaltered. The writer suggests that this is hardly scientific, but savors rather of the older deductive philosophy. Faraday thought it worth while to test the question, but he was led in the course of his experiment to a new discovery, and never pushed his work to a definite conclusion. This will be referred to later. But while there seems to be no direct experimental evidence on this point, there is indirect evidence to show that there is no change in weight (at least, in copper wires) to the extent of about 1 part in 1,000. This evidence is furnished by work that has been done with the current balance.

It is interesting to notice that the first person to use a current balance (Cazin in 1864)* seems never to have thought that there was a possibility of the weight altering when a current passed, as his original paper is silent on this point. In this he was followed by greater names (Joule, Helmholtz). That this question was considered by Faraday, even if he reached no conclusion, serves only to add to his reputation as an exponent of inductive methods in science.

Probably the best work on the current balance is that of Lord Rayleigh and Mrs. Sidgwick on the electro-chemical equivalent of silver.† Their value for this constant is 0.00111794. Fr. and W. Kohlrausch‡ determined the same, measuring the current against the earth's field by an accurate tangent galvanometer. Their value is 0.0011183. Patterson and Guthe§ measured the current against torsion, determining the latter by time of swing and calculated moment of inertia. Their value is 0.0011192. The close agreement of the first of these figures with the two others shows that no serious error could have been introduced by

* *Ann. de Chem. et de Phys.*, 1884, [4] 1, p. 257.

† *Phil. Trans.*, [2], 411, 1884; and *Proc. Royal Soc.*, 37, 144, 1884. Also Rayleigh's *Collected Papers*.

‡ *Wied. Annalen*, 27, 1, 1886.

§ *Physical Review*, 7, p. 257, 1898.

the assumption that the weight of a current-bearing conductor remains unaltered. In pronouncing this effect negative it must be borne in mind that the current density in the coils of the current balance must be quite small, in order that thermal disturbances may be avoided. It would be an interesting though difficult research to determine what effect, if any, a heavy current has on the weight of the conductor. Any one contemplating such a research will find a useful suggestion on the weighing of hot bodies in a paper by the present writer in the *Journal of the Franklin Institute* for May, 1898.

Let us next consider the electrical resistance of a conductor. As the question of there being any resistance when there is no current flowing is rather a metaphysical one it will not be discussed here, but we shall limit ourselves to the effect produced on the resistance when the current changes from a vanishingly small magnitude to a very great one. The question may be put in this way: Is Ohm's law accurate, or is the ratio $\frac{E}{C}$ not a constant, but a function of the current? Schuster, in England, believed that some results of his with a sine inductor pointed to the conclusion that Ohm's law was inaccurate, and the British Association appointed a committee, of which Maxwell was a member, to test the question. Their report * describes two methods of experimenting, the theory of which is due to Maxwell, while the actual experiments were performed by Chrystal. In the first method five coils of nearly equal resistance (about 30 ohms) were employed. Their ratios were carefully measured, and it was found that this could be done to about one part in four millions. If two of these coils be balanced against each other in a Wheatstone's bridge, the coils occupying the two lower sides of a quadrilateral diagram, the current strength in the coils will be equal when there is no current through the galvanometer. Now replace one of these coils by a set of four, arranged two in series and two in parallel, and when no current flows through the galvanom-

* *B. A. Report*, 1876, p. 36.

eter the current strength in each coil of this set will be one-half that in the single coil in the other arm of the bridge. Consequently, if the resistance be a function of the current strength, the single coil will not balance the set of four. In carrying out this method it seemed that there was a falling off in the resistance of about one part in 200,000 when the current was doubled in strength; but a large part of this was afterward found to be due to defective insulation. As for the rest, the results of the second method make it certain that it must be attributed to some unrecognized error of experiment.

The theory of the second method is developed mathematically by Maxwell in the "Report" already referred to. He shows that if there be two conductors of the same material and different cross-sections arranged in series and carrying the same current, any departure from Ohm's Law will be greatest in the conductor of smaller section, and if their resistances be equal for small currents they will not be equal for large ones. The ratio of their resistances is expressed by the following formula :

$$\frac{L_1}{A_1} \frac{A_2}{L_2} \left\{ 1 + s C^2 \left(\frac{1}{A_1^2} - \frac{1}{A_2^2} \right) + \dots \right\}$$

wherein L_1 and L_2 are the lengths, A_1 and A_2 the sectional areas of the two conductors, C the current in both, and s the coefficient of departure from Ohm's Law, which is zero if the resistance does not vary with the current. It will be seen from this formula that (neglecting some small higher terms) the resistances may vary and their ratio remain constant, provided their areas are the same. Consequently the two wires chosen were made to differ greatly in area, and their resistances were made about equal by having the fine one short and the coarse one long. These wires were joined in series as two arms of a Wheatstone's bridge and a heavy and a weak current were sent through them in rapid succession (about sixty times a second) by means of a tuning fork. This served to eliminate the heating effect, or, rather, to keep the wires at a constant temperature for both currents, as the wire had not time to cool during the passage

of the weak current before the heavy one had returned. A balance was obtained with this intermittent current, and the weak current was then reversed in direction, the stronger remaining unaltered. The balance remained undisturbed. This could only have taken place if the resistances were independent of the current; for if the resistances varied no true balance could have been obtained in the first place, and what appeared to be a balance would have been merely a stationary needle under the influence of a rapidly alternating current, which would be converted into a direct (though fluctuating) current upon the reversal of the weak current before mentioned. As a result of this method the committee was able to state that when the current varied from a vanishingly small value up to one ampere per square centimeter the resistance did not vary by as much as one part in a million million!

There are few laws in physics whose verification has been pushed as far as this. In this case the natural limit of the solid continuity of the conductor was almost reached, as the strong current heated the fine wire beyond redness. This is the more remarkable, as Ohm's law was originally entirely empirical, without any theoretical reason to render it probable.

There are two substances, mercury and carbon, whose specific heats are known not to vary appreciably when a current is passed through them. For mercury this follows as a corollary to the work of Barnes and Cooke* with the continuous flow electrical calorimeter. In this instrument a slender thread of mercury was heated by the passage of a current and the results agree with the best results of earlier methods to about 1 part in 300.† For carbon the writer has shown† that the specific heat is not altered by 1 part in 450 for a current density of about 150 amperes per square centimeter. His method depended on the fact that a small abrupt change of temperature might be expected if the specific heat changed suddenly when the current was started or stopped.

* *Physical Review*, February, 1903.

† *Science*, July 10, 1903.

So far, all the effects of the current upon the properties of the conductor have been negative. There are a few positive effects. These are the well-known magnetic effect discovered by Oersted and amplified by Ampère; the three heating effects known by the names of Joule, Peltier and Thomson, respectively, and an alteration of the surface tension of a liquid conductor discovered by Faraday.* The latter was attempting an experiment on the weight of a current-bearing conductor, and had suspended a coil beneath a scale pan with one free end dipping into mercury. On starting the current the coil became much lighter, which Faraday found to be caused by the fact that the mercury was not so strongly drawn up around the wire when a current was passing.

There may also be an alteration in friction between two surfaces across which a current passes, as in Edison's motograph or chalk-cylinder telephone receiver. In this instrument a palladium surface rests upon a cylinder of chalk which has been soaked in a solution of sodium phosphate, and which is kept slightly moist and continuously rotated. When a current passes the palladium slips more freely over the chalk. An electrolytic explanation has been offered for this phenomenon, which supposes that gases developed in the solution carried by the chalk are occluded by the palladium. In favor of this there is the well-known property possessed by palladium for occluding hydrogen, and against it the fact that the instrument works best in the secondary circuit of an induction coil; also against it is the fact that the action is reversible, and a "motograph battery" has been constructed in which the friction of the palladium against the revolving chalk produced a current.

Passing now to the properties of current-bearing electrolytes, it has been shown by Faraday† that such a liquid has no effect on polarized light when the latter passes either across the current or in the same line with it. The electrolytes used were saturated solutions of sodium sulphate and lead nitrate.

* *Experimental Researches*, 2, p. 256.

† *Experimental Researches*, 1, p. 285, § 951 *et seq.*

Roiti,* Zecher† and Rayleigh‡ have investigated the speed of light in a current-bearing electrolyte with negative results. Zecher's paper the writer has not yet seen, as there is no copy of it in the Philadelphia libraries; but as Rayleigh remarks that his own work has been pushed farther than either of the others, it will be sufficient to consider his results. He used an interference method, employing dilute sulphuric acid and a current density of 0.26 amperes per square centimeter. He showed that for a current density of 1 ampere per square centimeter there could be no effect as great as 1 part in 13,000,000. He remarks that this result could be pushed somewhat further if there was any reason to expect an effect of that magnitude; but from the fact that the speed of light is 3×10^{10} centimeters per second and that of the swiftest ion (hydrogen) urged by a fall of potential of 1 volt per centimeter is about 10 centimeters *per hour*, the light wave could hardly be expected to know that the ions were in motion, the ratio of the speeds being something like one to ten million million.

Gladstone and others have shown§ that a current accelerates lagging chemical reactions, such as the precipitation of potassium acid tartrate and strontium sulphate; and Barus|| finds that it also promotes the settling of suspended matter.

Mills¶ and Bouty** have shown that metals may be electrically deposited in films under tension or the reverse by properly choosing the current strength; and the latter finds that in the electrolysis of a number of salts (CuSO_4 , ZnSO_4 , etc.), a current strength may be found, so that for greater currents the negative electrode is warmed, and for less cooled by the separation of the metals. For the same salts may also be found a limiting current-strength, so that beyond it the separated metal exerts a pressure, and below it a pull

* *Pogg. Ann.*, **150**, p. 164.

† *Repertorium der Physik*, **20**, p. 151, 1884.

‡ *B. A. Report*, 1888, pp. 339-360.

§ *B. A. Report*, 1887, p. 667; also *Nature*, **36**, 524.

|| *Bulletin U. S. Geological Survey* No. 36.

¶ *Proc. Roy. Soc.* **26**, No. 184, p. 504, 1877-78.

** *Comptes Rendus*, **92**, pp. 868-870, 1881.

upon that on which it is deposited. Moreover, these two neutral points are not identical for the same solution.

The present writer has shown* that crystals formed from a current-bearing electrolyte are not affected by the current, though they may be somewhat distorted by the accompanying heating effect in the liquid.

The foregoing seem to be all the properties of current-bearing solids and liquids that have been investigated. If any reader can supplement this bibliography, the writer would consider it a favor if he would do so, addressing him at the Central High School, Philadelphia. After reviewing what has been done in this field, many interesting research problems are suggested. Some of this work the writer has under way, and it would be well for intending workers in this field to correspond with him in order that useless duplication may be avoided.

HEAT WASTE FROM UNPROTECTED STEAM PIPES.

According to careful experiments made by Prof. S. P. Thompson, a square foot of uncovered steam-pipe filled with the vapor of 100 pound pressure will radiate and dissipate in a year the heat put into 3,716 pounds of steam by the economic combustion of 398 pounds of average coal. Thus, 10 square feet of bare pipe corresponds approximately to the waste of 2 tons of coal per annum. Another experimenter, testing the various materials employed for wrapping, concludes that the saving in condensation effected with the best form of mica covering is nearly 88 per cent.—that is, calling the loss of heat with bare pipes 100, the loss when wrapped with mica-packing would be 12. Asbestos covering seems to be considerably inferior to mica, and cements less desirable than either.

WATER JET AS A CURRENT CARRIER.

The danger from electricity, particularly for the firemen in directing a stream of water upon an object carrying electric current, was the subject of an article in a recent issue of *Energie*, of Berlin, recording the results of a number of tests. A man wearing wet shoes and standing on a wet plank flooring, threw a jet of water on an electrified plate. At 500 volts and an aperture of 0.74 inch in the nozzle, he felt the current at a distance of $2\frac{3}{4}$ feet, and with an aperture of about 2 inches could not get nearer than about $3\frac{1}{4}$ feet. Under the same conditions, but with alternating current, he could not stay within 8.2 feet, and at 3,600 volts he had to remain at a distance of $26\frac{1}{4}$ feet.

* *Physical Review*, 15, No. 6, December, 1902.

ELECTRICAL SECTION.

Stated Meeting held Thursday, October 8, 1903.

Rail Bonds.

BY W. E. HARRINGTON.

General Manager Camden and Suburban Railway Company.

(Continued from p. 120.)

"UNITED STATES" RAIL BONDS.

The "United States" rail bond is made with solid terminals and flat strips of copper, and is so designed that it can be used inside the splice-bar of a rail-joint when the plate is only $\frac{1}{4}$ of an inch from the web of the rail. The leaves of the bond will fit into a space which is only $\frac{1}{5}$ of an inch in thickness. These features make the bond applicable to certain cases in which strands cannot be used satisfactorily. This bond is applied to the rail with a compressor. The "United States" bonds are bonds in which copper strips and welded terminals are used.

Fig. 38 shows top surface of terminal of this type of bond.

Fig. 39 shows the appearance of terminal after insertion in the hole and before compression.

Fig. 40 shows the appearance of the terminal after compression.

Fig. 41 is a section of rail web and terminal showing the result when the compression has been completed properly.

Fig. 42 is a bond of this type made in lengths from $5\frac{1}{2}$ to 14 inches inclusive. Lengths greater than 14 inches are considered special, and made only to order.

The screw compressor for applying the "United States" rail bonds is shown in *Fig. 43*.

Style "A" compressor. Weight, 83 pounds. For T- and girder-rails 7 inches or less in height. Style "B." Weight, 125 pounds. For T- and girder-rails 9 inches or less in height.

GENERAL ELECTRIC COMPANY BOND.

General Electric Company bond is made by pouring molten copper around about wire strands of body and about an iron

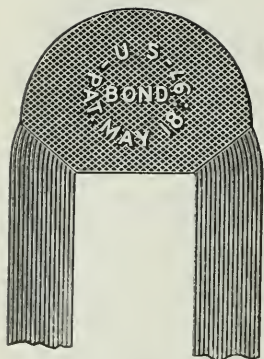


FIG. 38.

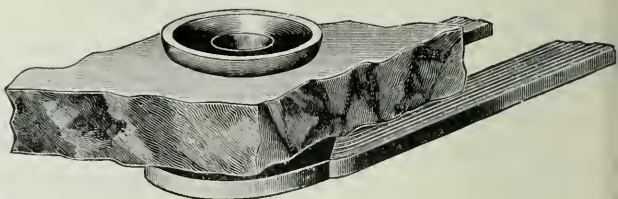


FIG. 39.

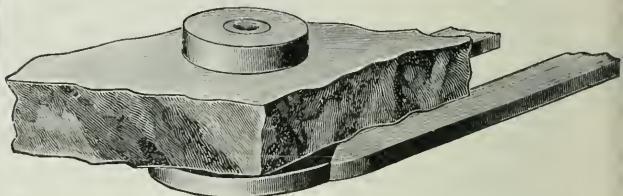


FIG. 40.



FIG. 41.

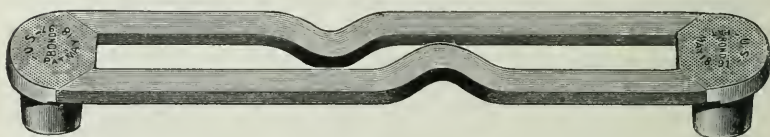


FIG. 42.—“United States” rail-bond. Style No. 3.

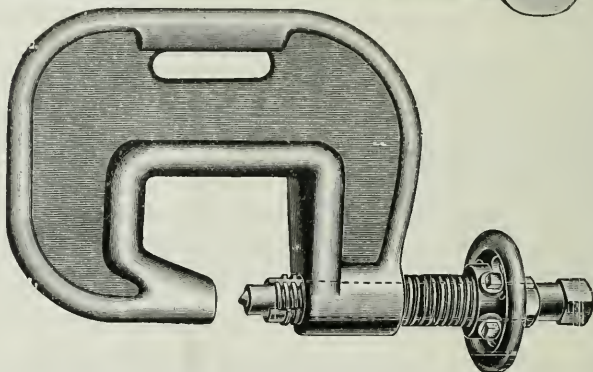
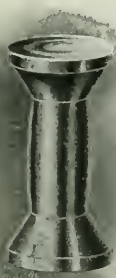


FIG. 43.—Screw compressor for applying bond.

plug, which extends through the axis of, and becomes part of the cast terminal.

FIG. 44.—*a*.FIG. 44.—*b*.

Steel core before and after compression.

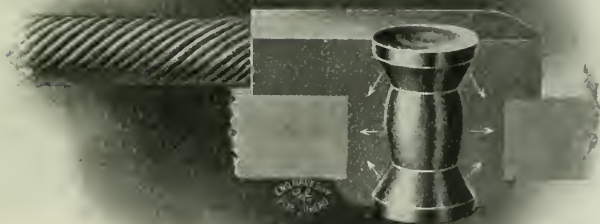


FIG. 45.—Section through rail bond showing effect of compression.

Figs. 44 to 49 show different forms and applications of this type of bond.

Figs. 50 and 51 show the soldered flexible rail bond. It

is formed of a series of flat strips of annealed copper bent in the form of an arch to ensure the greatest degree of flexi-



FIG. 46.

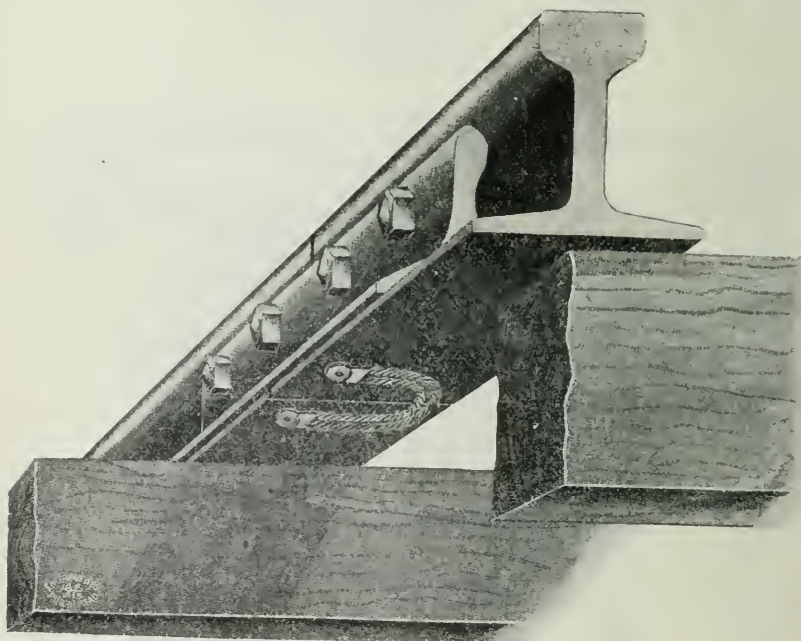


FIG. 47.—Form C bond under bottom flange for extreme flexibility.

bility, with a pair of flat feet to provide a contact surface. The strips of each foot are soldered together, making a solid terminal, while the intermediate strips of the arch are un-

attached to each other. The feet of this bond are soldered to the rails.

Outfit. An outfit for placing this bond comprises one special rail-cleaner and emery wheel, one special blow-torch, one wind-guard, clamps, solder and acid.

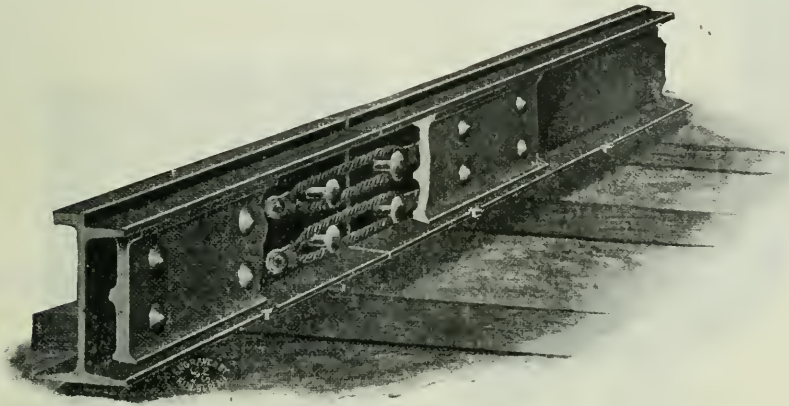


FIG. 48.—Form B bond under fish-plate.

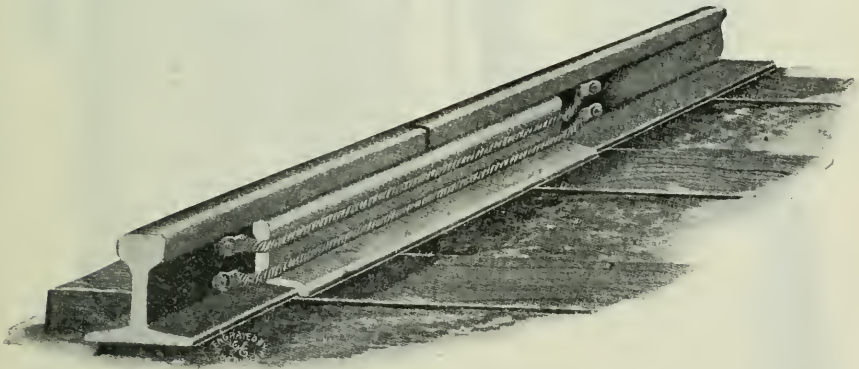


FIG. 49.—Bonds spanning fish-plate where there is insufficient room between rail and fish-plate.

Instructions for placing: (1) Clean the two surfaces of the rails where the bonds are to be applied by scraping with a file or by an emery wheel run on a flexible shaft as shown in *Fig. 52*. These surfaces must be made perfectly clean and bright, free from rust, etc., and should be slightly



FIG. 50.—Soldered flexible rail bond.

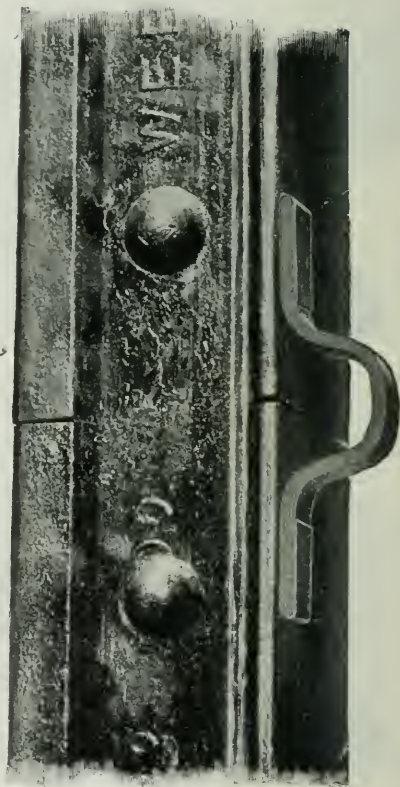


FIG. 51.—Soldered flexible rail bond.

larger in area than the contact surfaces of the feet of the bond. The bond should be bent so that the feet shall lie true on the cleaned surfaces, and should be 7 inches in extreme length when applied.

Heat is applied to these surfaces by means of a special blow-torch, *Fig. 53* (using wind-shields, *Fig. 54*, when necessary to protect the burners), until the surfaces have reached a temperature when solder will melt. This takes but a few minutes, and can be determined by rubbing a stick of solder on the heated parts. When the solder runs freely, the sur-

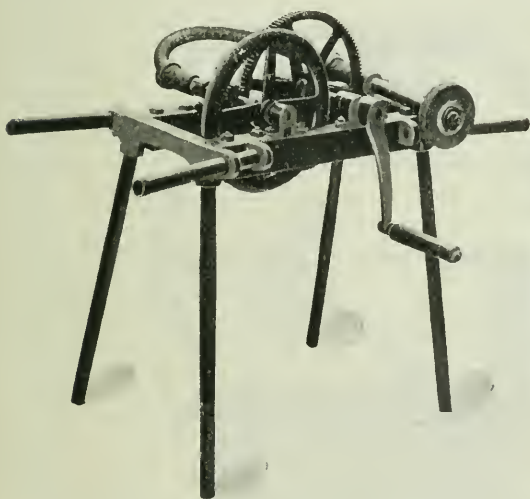


FIG. 52.—Hand grinder, flexible shaft and emery wheel.



FIG. 53.—Osborn torch.

faces are rubbed with a flux (preferably zinc cut with muriatic acid), then the solder is applied until the surfaces are thoroughly tinned.

The bond is placed in position, with the feet in level contact with the tinned surfaces, the strip of thin solder which is attached to the foot of the bond having first been lifted and the foot cleaned with a brush wet with the acid solution.

Heat is applied to the feet of the bonds until the layer of solder runs. A brush wet with soldering acid is then passed around the edges of the feet to bank the solder which

squeezes out, making a uniform junction between bond and rails. (Pressure should be applied to the feet of the bonds during the process. If the bonds are applied to the bottom of the rails, they are held in place with the special clamp shown in *Fig. 55*, but during the operation of bonding new construction the pressure is not applied until the solder is thoroughly melted.)

When the solder is set, the pressure is removed and the metal cooled gradually by first pouring water on the rail near the bond. Water should not be put directly on the solder

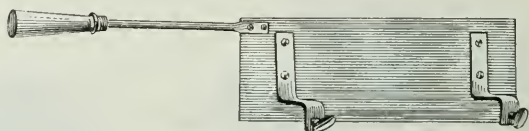


FIG. 54.—Wind-shield.



FIG. 55.—Standard clamp.

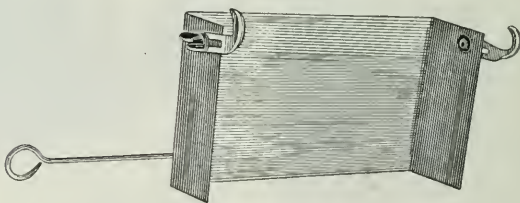


FIG. 56.—Wind-shield for bonding during construction.

until it is thoroughly set, else there is a tendency to crystallize. Finally, the bond is washed to remove all acid. The bond has now a firm and enduring contact.

In new construction where joints are to be suspended, it is best to connect together by the joints or fish-plates, about 10 rails (if 30 foot), forming a section which can easily be turned over by four men. This section is turned bottom up, and after the bonds are applied, turned back and spiked in place. Before doing this, however, each end of the section should be cleaned and tinned so that the bond connecting

the various sections can easily be applied after the track is in place.

The wind-shield and special torch employed in new construction are shown in *Figs. 56 and 57*.

AMALGAMATED BONDS.

Description. The solid copper bond, *Figs. 58 to 62*, is made of a rectangular plate of rolled electric copper, 3 or more inches long, $\frac{1}{8}$ of an inch thick (or thicker) and $1\frac{1}{2}$ or more inches high. A cup-shaped projection is pressed near each end so as to give a contact against rail-web close to the

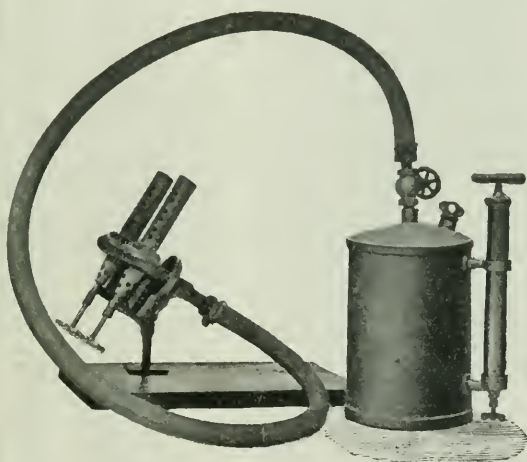


FIG. 57.—Osborn torch, with additions for underneath bonding when track is spiked down.

end of each rail. Next to the copper is a piece of sheet steel supporting a pair of special steel springs: the steel is used to keep springs from wearing into copper. These pieces are held together by a small steel staple passed over the center of bond and driven into a cork composition plate which is longer and wider than the metal and serves to exclude dirt from the contact surfaces and to hold the springs in position.

All metal parts of bond are amalgamated to prevent rusting, and the contact surfaces are covered with plastic alloy. The bond is always laid out to suit each particular rail and joint, and does not interfere with the mechanical

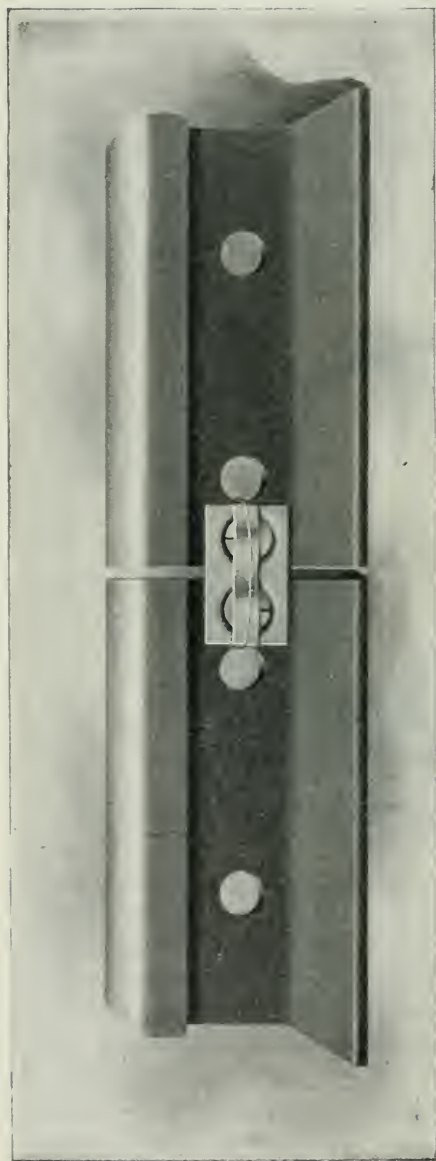


FIG. 58.—The solid copper bond without cork, ready for angle-plate.

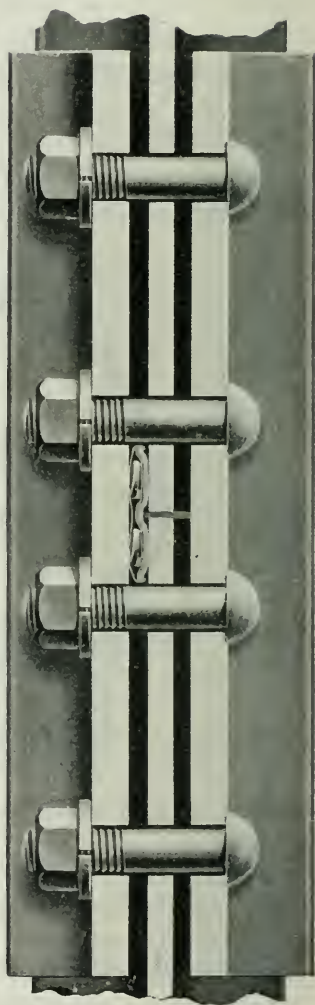


FIG. 59.—Horizontal section through center of bond.

fit of angle-plate. When in service the springs serve merely as distance pieces so long as joint is tight; if nuts loosen or plates wear, the springs still hold bond in contact. Then tightening the track nuts also tightens the bond. The use of spring-lock washers is advised on track nuts to

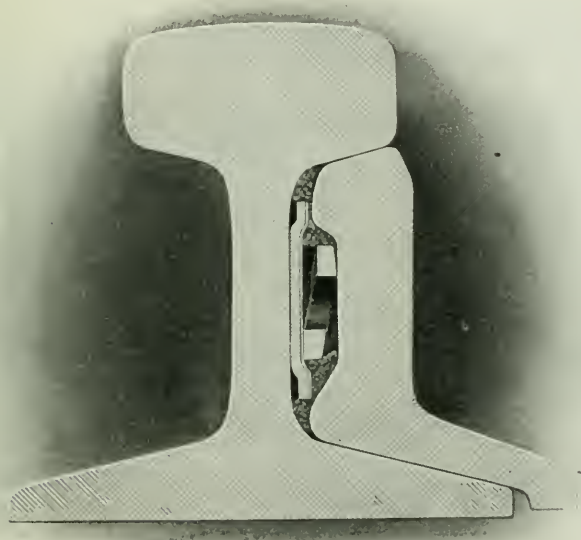


FIG. 60.—Vertical section through center of bond contact.

keep them fast; these washers will then take up the wear of the plate.

Where clearance between web of rail and angle-plate will not permit the use of springs, a plate of flexible cork is placed so as to overlap the copper on top, bottom and sides and give sufficient pressure to maintain the contacts. (See *Fig. 61.*) Another cork plate is placed between rail-ends to keep out dirt.

To apply this bond it is only necessary to brighten web

of rail beyond end bolt hole with a hand-power grinder and flexible shaft with emery wheel. The surfaces are then amalgamated and covered with a thin layer of plastic alloy. The lubrication afforded by the plastic alloy permits the rails to move in any direction without wearing away metal of bond.

Sizes. The size of copper is varied to suit requirements up to the full area of the space between rail-web and angle-plate, and between end of bolt holes in rail.

Bonds with copper plates over $\frac{3}{16}$ of an inch are not cup-shaped, but have a shallow outward bend opposite ends of

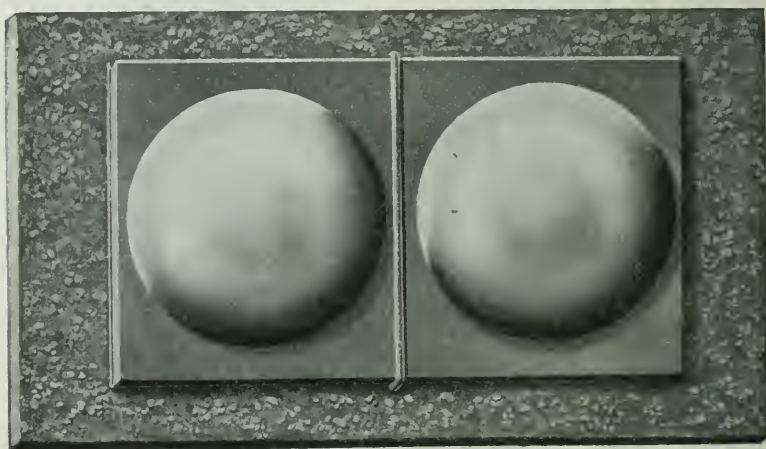


FIG. 61.—Front of No. 5/0 solid copper bond, full size, with cork plate.

the rails; this avoids scraping bond against sharp rail edges.

The bond shown in *Fig. 61* has a vertical cross-section of more than 0.218 of a square inch, while the section of a No. 4/0 wire is but 0.166 of a square inch. The bond, therefore, has a greater conductivity than $1\frac{3}{10}$ No. 4/0 copper wires.

Conductivity. It has been claimed that one No. 4/0 solid copper bond laid upon amalgamated contact spots on head of 80-pound T-rail so as to bridge the joint, carried 2,000 amperes with a drop of .018 volt. The drop of 1 inch of this rail with the same current was .00223 volt. The

bond merely laid on top of rail and held in contact by *nothing but its own weight* was equal in resistance to but $8\frac{1}{4}$ inches of rail. The drop of unbonded joint, with same current, was .423 volts.

Guarantees. Manufacturers guarantee that the bond will transmit current at the rate of 2,000 amperes per square inch of vertical section without heating beyond temperature of rail.

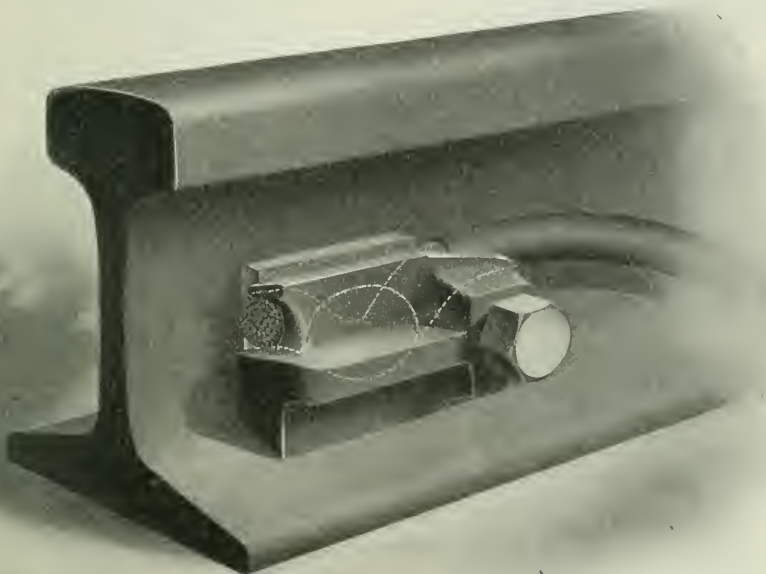


FIG. 62.—Cast-iron feeder terminal.

They further guarantee under above conditions that at the end of two years' service, the conductivity of the bond will be practically the same as at the start, provided the joints have been mechanically maintained in proper condition for operating cars.

Cross Bonds. Copper cross-bond terminals for No. 2/0 and No. 4/0 wires. These are fastened to rail web with $\frac{3}{8}$ -inch bolts, whose ends should be riveted after nuts are set tight. The end of the wire is amalgamated and slipped

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through hole in lug upon bottom of terminal. A round-nosed tool is placed at right angles to wire in the hole below bolt-hole and the wire kinked by a hammer blow, forcing it into a cored cavity. The hole is then filled with plastic alloy and the terminal bolted against amalgamated contact spot on rail web.

On exposed road where copper track wire might be stolen, use a steel cross bond $1\frac{3}{8}$ inches square, which cannot be removed without special tools.

For rail feeders and loops around crossings, switches and special work, use cast-iron terminals for one or two No. 4/0 wires and for 250,000 and 500,000 C.M. cables. These hold a cork case against web of rail, forming a receptacle into which is placed the end of the wire and some of the plastic alloy. In each case the wire ends are amalgamated, as are also the contact spots on web of rail. These terminals are fastened to rail web with $\frac{3}{4}$ -inch bolts, whose ends should be riveted after nuts are set tight.

PLASTIC RAIL BOND.

For track with heavy rail and angle plates, this bond, *Figs. 63-66*, is composed of two portions: a plastic alloy or putty-like metal compound which makes contact between the rail and the splice bar or angle plate, and a flexible, elastic cork case to hold the same in position as near end of the rail as possible. The initial thickness of the cork case is nearly double the distance between web of rail and inner surface of angle plate; it is therefore compressed about 40 per cent. when in place and after pressure has been applied it adheres to the rail and plate, completely sealing the plastic alloy.

The cork case is made of a compound of cork and oxidized linseed oil and is practically indestructible. It is elastic and will maintain seal even when plate has loosened $\frac{3}{16}$ of an inch.

The current passes from one rail through one plug to the angle-plate, and then through second plug from the plate to the next rail (see arrows in *Fig. 73*). Contact spots about 2 inches in diameter on both rails and angle plates are



FIG. 63.—Plastic rail bond ready for application.



FIG. 65.—Completed joint with plastic plug bond.

cleared of scale and rust and treated with the solid alloy, which instantly silvers the surfaces and prevents them from rusting. This fills the surface irregularities and penetrates the metals for a perceptible distance, leaving a surface to which the plastic alloy adheres.

Plastic-plug Rail Bond. This can be used on all forms of rail where the fish-plate overlaps rail base by 1 inch or more. Several different forms to meet varying requirements are shown in accompanying cuts, *Figs. 65-66.*

The application of the plastic-plug bond is made after the completion of the track, so that delay through interference of two different gangs is avoided. Between the first and second bolt holes from the end of each rail, a hole $\frac{3}{8}$ to

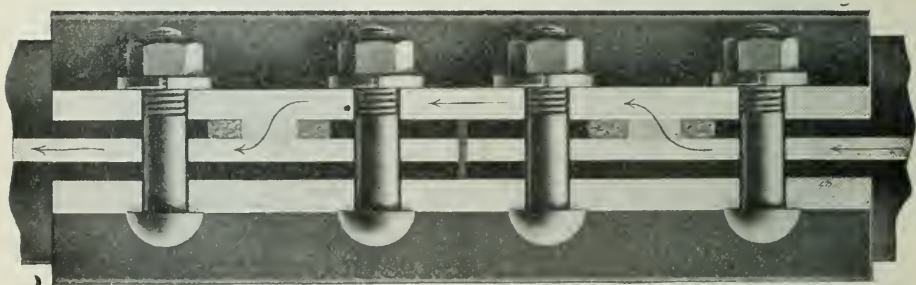


FIG. 64.—Horizontal section.

$\frac{1}{8}$ of an inch in diameter is bored diagonally downward through the flange of angle plate, into, but not through, the base of rail.

The hole is nearly at right angles to plate flange and as near the vertical web as possible. An ordinary ratchet drill and a J-shaped clamp passing under the base of rail are the only tools necessary. The drill point is lubricated with a solution of pearline and water instead of oil, so as to avoid the trouble which follows the use of an insulating fluid on metal contact surfaces, and the hole is usually drilled to $\frac{1}{8}$ of an inch from bottom of rail base. The drill chips are removed with a permanent magnet, and the proper depth determined by template or collar fastened on drill. The plates may be drilled before distributing along the road;

this is more than double the number of joints which can be bonded in a day.

After the hole is drilled it is amalgamated by filling with water and rubbing with the end of a rod of the solid alloy. On bonds of large diameter, an amalgamated copper tube is driven into the hole so as to completely seal the crack between the meeting surfaces of rail and angle-plate as shown on right side of *Fig. 12*. This is unnecessary with the small sizes. The hole is then partly filled with the plastic alloy, which adheres to the amalgamated surfaces of the steel.

An amalgamated copper plug, which is T-shaped in section, is then driven to seal the hole and to complete the

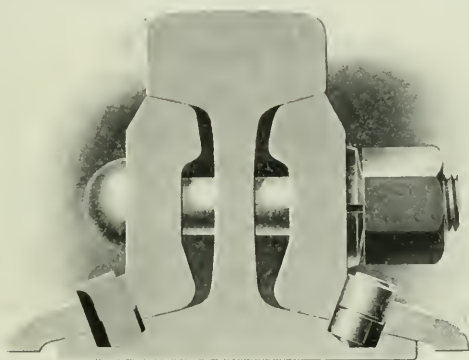


FIG. 66.—Section of plastic plug bond.

circuit between the rail and angle-plate by dipping into the plastic alloy. It is locked in place by a hammer blow on a blunt chisel, making a burr in angle-plate just above the top of the plug.

Fig. 65 shows completed joint with standard plastic-plug rail bond. *Fig. 66* shows section of same. In one form of this bond the lower part of the plug is a little out of center with the top, since less clearance is required on the inner side of hole because further motion of angle-plate inward can occur only after rail and plate surfaces have worn. This eccentricity allows a groove to be made in top of the plug, and this groove should always face the outside of the rail. The grooves serve to prevent air binding as plug is driven

home, and are then closed by a tap of the hammer on the edge.

There is a modification called the plastic screw plug for very heavy rails carrying steam road service on bridges and in tunnels, in which provision is made for easy examination and repair. The hole in plate is of larger diameter and is screw-threaded and amalgamated before distribution along the road. A hardened steel jig is screwed into hole to properly locate rail drilling. When this hole is drilled and amalgamated a copper tube is driven home and around the top of the tube is placed a diagonal strip of elastic packing. The hole is then partly filled with the plastic alloy and the plug screwed down to compress the packing and seal the joint.

[To be concluded.]

SELF-HARDENING STEELS.

One of the recent notable developments in the metallurgy of steel has been the manufacture of what is known as self-hardening or high-speed steels, which are adapted for tools working at a high rate of efficiency. There is a great variety of these steels on the market, and they show wide differences in composition, although usually containing some of the rarer metals, such as tungsten, molybdenum and chromium. Tools made from these steels can work without injury at a temperature of 500° or 600° C.

THE MT. VESUVIUS RAILWAY.

What is said to be the most dangerous railway in the world is that recently completed up the side of Mt. Vesuvius for the benefit of the many tourists who annually visit this famous volcano. It is a cable railway of the mono-rail type, the one car comprising the active rolling stock being supported by two wheels, one at each end of the car. The center of gravity of the car is below the top of the supporting rail, so that it balances without the aid of supporting wheels at the sides. The railway line runs to within nominally 1,000 feet of the crater mouth, but the distance changes from day to day on account of the rapid changes that take place; accretions to the sides of the crater may materially increase the distance one day, and the fall of a huge slice into the seething gulf 500 feet below may considerably lessen the distance the next day. The maintenance of the line in proper alignment is a difficult matter. Fissures opening, the flow of lava, falling cinders, and sliding of the roadbed require constant watchfulness and labor by gangs of laborers who constantly patrol it during the periods of operation. The "train" has no fixed time-table, the trips depending on the activity of the volcano and direction of the wind; some days they are entirely abandoned.—*Machinery*.

CHEMICAL SECTION.

Stated Meeting, held Thursday, October 15, 1903.

A Basic Reaction of Aromatic and Fatty Aldehydes.

BY SAMUEL S. SADTLER.

While carrying on some work in oils of orange and lemon, I found it very difficult to get accurate determinations of the citral in certain of these oils. They were so-called oleo-resins of orange and lemon, which contain a relatively large percentage of acid resins, and have not to my knowledge been, as yet, described. These oils are obtained by extraction with a volatile solvent, which seems to dissolve certain constituents from orange and lemon peel, which either are not extracted at all, or else in smaller proportion by the processes of expression. It is recorded as a fact that the gravity of machine-expressed oil is greater than hand-pressed, and these oils are heavier than either.

With the use of sodium bisulphite for determining the aldehydes the addition compound forms partly in the aqueous layer and partly in the oily layer, and further work is very discouraging when this stage is reached. I soon tried sulphite of soda instead of the bisulphite. On heating a solution of this with the oil, the dihydrodisulphonate of sodium is formed, which is soluble in water, and two molecules of sodium hydrate are split off. Tiemann, in his work on the aldehydes of lemon-grass oil, pointed out that the reaction could be indicated by phenolphthalein, and by adding a solution of sulphurous acid from time to time, the end of the reaction could be known and the difference of volume of the oil could be told. This, however, is not a method that is capable of the greatest accuracy, and requires a special form of flask.

It occurred to me that the alkali formed in this reaction might be titrated for with standard acid, omitting the bicarbonate of sodium used by Tiemann. I first tried this with a standardized solution of sulphurous acid, but later found

$N/2$ HCl, or normal HCl, very satisfactory and more convenient. It seems to require the use of more sulphite solution, however, as the sulphurous acid reforms sulphite from the NaOH split off. I will try, however, at a future time, to take up all the details necessary in the determination of citral as a matter by itself, and speak of the general procedure more especially at present.

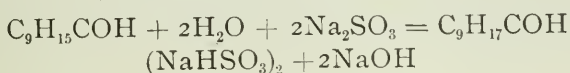
From other tests on the oils in question, I found that they contained considerable quantities of acid resin, which would, unless previously neutralized, interfere with the results. In fact, I found the acid resin of the orange oil almost sufficient to neutralize all the alkali formed. This difficulty was overcome by neutralizing these acids first with dilute caustic potash solution ($N/2$ KOH being convenient for the purpose, and if done quantitatively, might be interesting as part of a more or less complete examination of the oil) and rosolic acid solution as indicator, which will serve as indicator in the subsequent reaction.

Analyses were made with oil of orange, but until the mixtures of aldehydes of this oil are more fully studied, I will not refer to figures obtained. If citral is not found to be the predominating aldehyde, the results would be of little value except as comparative.

For oil of lemon, 5 or 10 grams are weighed into an Erlenmeyer flask, and after neutralization, 25 or 50 cubic centimeters of a 20 per cent. sodium sulphite solution, depending upon the amount taken, is added. Before adding the sulphite solution, however, it is neutralized with a little $N/2$ HCl, after being heated by immersion in a water bath. The sulphite solution used in these experiments required about 75 cubic centimeters of $N/2$ HCl to neutralize at boiling temperature, with rosolic acid as an indicator. When the solutions were mixed a red color formed at once in the aqueous layer. This was discharged from time to time with $N/2$ HCl. The flask is then heated and agitated frequently. The reaction is complete in about half an hour, if kept hot, and the layers mixed frequently. When the color is all discharged, or all but a very faint pink, which is not appreciably affected by a few drops more of acid,

the number of cubic centimeters of standard acid is noted. An emulsion forms, due to the neutralized resins, but that does not interfere with the reaction, if care is exercised.

The reaction, as written by Tiemann, is:



and is probably correct, as the amount of citral and sulphite is shown below to be in the ratio of 1 to 2.

The amount of standard hydrochloric acid used expressed in terms of citral, in the above ratio of one molecule of citral to two molecules of HCl, divided by the weight of oil taken, gives the percentage of citral.

Analyses of citral in lemon oil, by this method, gave in two determinations:

	Per Cent.
I.	5'24
II.	5'29

I believe results within one or two tenths of a per cent. can be gotten in every case, with a little practice, by this method.

To check the accuracy of this reaction, I made some known mixtures of citral, which was kindly furnished by Dr. Harry F. Keller, and separated lemon-oil terpenes, previously freed from citral.

	Calculated.	Found.
I.	8'68	8'85
II.	12'11	12'15

The method was further checked by using some pure well crystallized vanillin (M. P., 81° C.). The phenolic hydroxyl of the vanillin was first neutralized with a little caustic potash solution until it became a faint pink, using a little rosolic acid, sulphite solution added and titrated hot with N/2HCl, having first neutralized the sulphite solution at water-bath temperature as in the case of citral.

	Calculated.	Found.
Vanillin	100'00	99'00

This was a rough check on the method, but as the vanillin had not been specially purified further examination

of the reaction with vanillin, vanilla extract, and samples of vanillin mixed with coumain and acetanilid will be undertaken.

The reaction is almost complete in the cold with vanillin and merely needs heat to complete the reaction more quickly. Standing a short time might have given the same results.

The reaction seems to be immediate and complete with fatty aldehydes. It will indicate the presence of 1 part of formaldehyde in 1,000,000 parts of water, and when contained in food products the formaldehyde can be detected in a distillate of the same. The writer was able to detect formaldehyde in a solid product, partly made from milk, by first distilling with steam, neutralizing any free acid in the distillate with alkali, adding neutral sulphite solution and indicated upon which the presence of NaOH found in the reaction is clearly shown and can be accurately titrated for by means of standard acid.

Besides detecting and determining formaldehyde in milk a neutral sulphite solution used as a reagent is very useful.

The presence of acetone may be detected in wood spirits and determine acetic aldehyde in grain spirits. I noticed that a sample of grain alcohol, which, even after being carefully distilled over lime, gave a very brown color when made up into alcoholic potash, gave a very strong red coloration when mixed with sulphite solution and phenolphthalein.

Acetone and higher ketones were found to react, but further work on the various applications of this reaction must be taken up with the various substances in detail.

Referring again to essential oils, the reaction seems to be applicable to any essential oil, the single or predominating constituent of which is known, such as cinnamon, bitter almond oil, lemon-grass oil, cassia, etc.

Correspondence.

DOES CAST IRON GROW?

To the Committee on Publication :

GENTLEMEN.—I address you herewith in regard to the interesting paper read by Mr. Alexander E. Outerbridge, Jr., at the Section meeting, held Thursday, January 7, 1904.

The title, "Recent Investigations and Discoveries in Cast Iron," is well chosen ; but there is a certain enigma in it which this able metallurgist was not able to solve nor account for.

Of course, under such conditions, chemists as well as physicists hide themselves most successfully behind the molecules or the atoms, some kind of an hypothesis, which may be used for further attempts to find the truth, if possible. Mr. Outerbridge has found that *iron will grow*, when repeatedly heated and slowly cooled, a fact long since known, but never explained satisfactorily by a physical cause. The many experiments and measurements recorded by Mr. Outerbridge are well worth reading ; and, as in some cases a growth or expansion of 35 per cent. in cubical dimensions occurred, certainly gives the reader something to think about. (See *Jour. Frank. Inst.*, February, 1904, page 133, *et seq.*)

Now, the remarkable growth in cubical dimensions of cast iron on repeated heating ought to be explainable on physical grounds.

The following short story will show my view on the subject :

On Thursday, February 4, 1904, Dr. William Campbell, of Columbia University, New York, delivered a lecture before the Mining and Metallurgical Section, on "Results of a Research on the Structure of Metals and Alloys." He illustrated the lecture with a large number of well-prepared slides.

I don't think I ever saw better slides prepared ; indeed, they were exceptionally good, inasmuch as every detail could be recognized of the structure of the metal specimen photographed ; so much so, that the crystallizations were so well defined that I, for my part, was delighted to see them.

Now, there was a slide in which the cast-iron plate after polishing must have been well washed ; because I saw longitudinal depressions or holes which were perfectly clean and, strange to say, reflected light from within. There was not only one, but a good many ; I could not count them, since one slide followed the other at short intervals. These hollow spaces may have been looked upon as if they had been crystals or some of the eutectic mass ; but to my vision they were hollows or cavities.

You may depend upon it, that those cavities were formed by a gas or a mixture of gases during the preparation of the iron.

Assume now, if you please, any piece of cast iron having cavities filled with any mixture of gases which cannot escape when cold nor when heated ; is it then to be wondered that the gases will expand in all directions within the vessel in which they are enclosed ? and is it any wonder, that by every renewed heating the gases will re-expand and will exert the high pressure against the cast iron in which they are enclosed ? This seems to me to be the

fact in regard to the growth of a piece of cast iron when heated repeatedly; then, so long as the heating will be repeated the growth or the expansion of the cubic contents of the piece of iron will continue? No! there must be a limit to the action of the gas, and that is when the cavities become too large and the pressure on the iron walls of the cavities must cease.

Yours respectfully,

E. GOLDSMITH.

658 N. TENTH STREET,
PHILADELPHIA, February 11, 1904.

Notes and Comments.

ELECTRIC RAILROAD CAR LIGHTING IN GERMANY.

As a result of many tests of various systems of railroad car lighting in Germany, the Prussian State Railway Administration has finally settled on a direct system of lighting from a single generator with a steam-driven dynamo, located on the locomotive, under the control of the engineer; also auxiliary or regulating storage batteries placed on each car of the train, thus rendering the lighting system on each car practically independent, its lights being assured a constant supply of current from its own accumulators, which accumulators are kept charged by the dynamo on the locomotive. It is stated that this combination meets more perfectly than any of the others the requirements of simple, economical and efficient construction, maintenance and attendance in regular service.—*Iron Age*.

ACETYLENE FROM CALCIUM CARBIDE.

A yield of 5 cubic feet of acetylene gas from every pound of calcium carbide is guaranteed by manufacturers in the United States. In Germany acetylene gas is mixed with a gas of lower candle-power, containing about 25 per cent. acetylene, and used in railroad cars.—*Engineering and Mining Journal*.

Franklin Institute.

[*Proceedings of the stated meeting held Wednesday, February 17, 1904.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, February 17, 1904

Vice-President JAMES M. DODGE in the chair.

Present, 106 members and visitors.

Additions to membership since last report, 16.

The following resolution was adopted with unanimity:

“*Resolved*, That the President and Secretary be directed to extend to our sister Society, the Maryland Institute for the Promotion of the Mechanic Arts,

in Baltimore, the sincere regrets and sympathy of the Franklin Institute for the misfortune it has suffered in the destruction by fire of its building and equipment, and to express the hope that the Maryland Institute may speedily recover from this disaster, and enter upon a new career of usefulness."

The discussion announced for the evening was opened with a brief paper by Mr. Charles Day, on "The Electric Motor in the Machine Shop," which was illustrated by a number of lantern photographs, showing a variety of modifications of motor driving, adapted to meet the varying conditions found in machine shops.

Mr. Day was followed by Mr. H. B. Emerson, of the General Electric Company, Schenectady, N. Y.; Wm. Cooper, Cincinnati; Prof. Wm. D. Marks and others.

Mr. C. J. Reed described and exhibited in operation a "Variable Speed Controller" of his invention, which is designed to meet the requirements of motor driving.

The paper, with discussion thereon, has been referred for early publication.

The recent destructive fire in Baltimore was the subject of comment by Mr. Wm. McDevitt, Chief Inspector of the Philadelphia Fire Underwriters' Association, Dr. Henry Leffmann and Mr. Louis E. Levy. The latter exhibited and explained a number of lantern photographs, which illustrated the character and extent of the conflagration. Dr. Leffmann made a comparison of the areas covered by a number of the great fires in various cities of the world, which have become historic by reason of their magnitude and destructiveness. Mr. McDevitt treated the subject from the viewpoint of the fire and insurance expert.

The chairman announced the appointment of the several standing committees of the Institute for the current year.

Adjourned.

WM. H. WAHL,
Secretary.

Committee on Science and the Arts.

(Abstract of the proceedings of the stated meeting held Wednesday, February 3, 1904.)

MR. CHAS. E. RONALDSON and PROF. LEWIS M. HAUPT in the chair.

Prof. Lewis M. Haupt was elected chairman of the committee for the current year.

The following reports were acted on :

(No. 2164.) *Steam Generator.* John C. Parker, Philadelphia. Final action postponed.

(No. 2246.) *Enclosed Arc Lamp.* John Allen Heany, Philadelphia. Referred back to sub-committee.

(No. 2255.) *Joint for Rail-bonding.* C. B. Voynow and H. B. Nichols, Philadelphia.

ABSTRACT.—This method of making joints for electric railways is the subject of letters-patent of the United States, Nos. 673,649 and 673,829, May 7, 1901. It consists essentially in a preliminary cleaning of the parts of fish-plates and rail ends from scale, etc., by means of the sand-blast, and then pouring into the joint molten zinc, to make a firm union of the parts and a joint of high electric conductivity. All the mechanical details of the operation are cleverly worked out with the aid of a portable outfit of drilling and reaming machines, sand-blast apparatus and spelter-melting and pouring vessels. The details cannot be more fully described without illustrations.

The system has been adopted by the Philadelphia Rapid Transit Company with success. The report gives an account of a series of electric tests of resistance of the Voynow-Nichols joint conductor for the committee by Prof. Arthur J. Rowland in the Electrical Laboratory of the Drexel Institute, and of a physical examination made by members of the committee over a considerable section of track. These tests yielded very satisfactory results.

The report concludes that this joint has the advantage over other continuous rail joints of being easily removed and replaced, and the material removed does not become scrap, but is available (except the rivets) for use in other joints. In view of the completeness of the way in which the invention—method and apparatus—has been worked out, the award of the John Scott Legacy Premium and Medal has been recommended to the inventors. (*Sub-Committee*.—T. Carpenter Smith, Chairman; Richard Gilpin, E. A. Scott.)

(No. 2279.) *Electric "Buzz" Fan*. S. S. Wheeler, New York. Action deferred.

(No. 2283.) *Under-feed Stoker*. Evan Wm. Jones, Portland, Oregon.

ABSTRACT.—This is a device for feeding fuel to a fire from beneath, and has been applied with conspicuous success to the furnaces of steam generators using soft coal, the system operating as a mechanical stoker to supply the fuel to the furnace automatically, and to consume it without the production of notable amounts of smoke.

The report is reserved for publication in full with illustrations, without which a detailed description would be unsatisfactory.

The invention is protected by a number of patents, of which United States patent No. 409,792, granted to E. W. Jones, August 27, 1889, covers the fundamental principles.

The report concludes: "In view of the fact that Mr. Evan W. Jones has done such good work in . . . the design of the under-feed stoker under consideration, and in view of the simplicity of the device from a mechanical standpoint, both in construction and operation," the award of the John Scott Legacy Premium and Medal is recommended. (*Sub-Committee*.—Kern Dodge, Chairman; James Christie, Henry F. Colvin, John M. Hartman.)

(No. 2298.) *Rapid Roller Copier*.—Yawman & Erbe Manufacturing Company, Rochester, N. Y.

ABSTRACT.—This machine is a device designed for the purpose of easily and rapidly copying letters, manuscripts, etc. The copying is done from an endless web of paper which, in operation, is automatically moistened by passing beneath a roller immersed in a vessel of water, and then pressed together with the letter or manuscript to be copied, between feeding and

pressing rollers. The machine is mounted on a convenient stand, and appropriate means are provided for regulating the tension on the copying paper, the proper alignment of letter and copying paper, etc.

The details cannot be more fully described without illustrations.

The report finds that this copier is intelligently and carefully designed and is a practical machine. It is protected by patents. The award of the Edward Longstreth Medal of Merit is granted to the manufacturers, the Yawman & Erbe Manufacturing Company. [*Sub-Committee*.—E. W. White, Chairman; Luther L. Cheney, Geo. S. Cullen, Louis E. Levy.]

(No. 2305.) *A Simplified System of Pitman Phonography*.—Francis J. Stein, Philadelphia.

ABSTRACT.—This system is described in a manual by applicant entitled a "College Course of Shorthand." The most radical change from the Pitman system is in the arrangement of vowels in respect to their position, and the resulting position of words.

Applicant abandons the method of regulating the position by the sound of the vowel, and substitutes a classification of the letters themselves without regard to their sound, thus ignoring the phonetic system so far as the vowels are concerned. The first group consists of all the sounds of the vowel *a*, and occupies first place, or above the line; the second comprises all the sounds of *e* and *i*, and occupies the second place, or on the line; the third comprises all the sounds of *o* and *u* and the diphthongs *oo*, *ou*, and *oi*.

The result is to change the position of the majority of the words of the language; but as the student has no knowledge of prior systems the new position creates no difficulty. The author claims for this the student is not hampered by the necessity of learning the various sounds of the vowels, and that he can without hesitation place the word in its proper place.

The obvious objection to this change is that words identical in their consonant outlines may be mistaken for one another, but the author claims that such cases would be few.

In the consonant signs, the principal change made by the author is in making the *l* and *r* hooks on the same side of the stems, distinguishing them by making the former uniformly large and the latter uniformly small. For this change increased speed and legibility are claimed.

Applicant takes the broad ground that fully 90 per cent. of those who learn shorthand do not need to know the requirements of the phonetic vowel scale, and that a lack of that knowledge will not prevent them from acceptably filling business positions.

The Committee recognizes the fact that facility in shorthand writing depends not so much upon the system as upon the thoroughness with which it has been learned and practiced, and that no great speed or accuracy can be attained until the forms can be written without conscious effort.

In consideration of the practical character of the manual, and the fact that the system has proved in practice to be a ready means of teaching shorthand to comparatively young pupils, a Certificate of Merit is awarded to the author. [*Sub-Committee*.—E. A. Scott, Chairman; Geo. B. Cock, George S. Cullin.]

(No. 2306.) *Nut-Lock*. James Walsh, Jr., Philadelphia.

An advisory report.

W.

Sections.

[*Abstracts of stated meetings.*]

MINING AND METALLURGICAL SECTION.—*Stated meeting*, held Thursday, February 4, 1904, 8. P.M. Mr. James Christie in the chair. Present, 38 members and visitors.

Dr. William Campbell, of Columbia University, New York, read a paper describing the "Results of a Research on the Structure of Metals and Alloys." The speaker illustrated his remarks by the exhibition of numerous micro-photographic views, showing the microstructure of a number of metals and alloys.

The paper was freely discussed by Drs. E. Goldsmith, Joseph W. Richards, and the author.

Prof. O. C. S. Carter, of the Central High School, followed with an interesting informal address, describing the Silicified Forest of Arizona and the Physical Geography of the so-called Painted Desert. His remarks were illustrated by numerous lantern photographs.

The thanks of the meeting were voted to the speakers of the evening. Adjourned. (To be published.)

G. H. CLAMER,
Secretary.

ELECTRICAL SECTION.—*Stated meeting*, held Thursday, February 11th. Mr. Thomas Spencer in the chair. Present, 48 members and visitors.

Mr. Adolphus A. Knudson, of New York, presented a paper on "The Corrosion of Metals Underground by Electrolysis."

The speaker illustrated his remarks by the exhibition of numerous lantern views. The subject was discussed by Messrs. Carl Hering, Spencer Fullerton, Thomas Spencer, and the author.

The Chairman extended the thanks of the meeting to the speakers of the evening, and the session was adjourned. (To be published.)

RICHARD L. BINDER,
Secretary.

CHEMICAL SECTION—SECTION OF PHOTOGRAPHY AND MICROSCOPY.—*Joint Meeting*, held Thursday, February 18th, 8 P.M. Dr. Henry Leffmann in the chair. Present, 42 members and visitors.

Mr. Robert Job, of Reading, Pa., Chemist to the Philadelphia and Reading Railway Company, presented the "Results of an Investigation of Paints for the Protection of Structural Work." The author's results were derived from an extended microscopic study of paints of various standard compositions, and of the various materials (barytes, gypsum, clays, etc.) used as "fillers." The subject was illustrated by the exhibition of a series of photographs projected on the screen.

A lengthy discussion followed. (The paper is reserved for publication.)

W. E. RIDENOUR,
M. I. WILBERT,
Secretaries.

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THE FRANKLIN INSTITUTE.

Stated Meeting, held Wednesday, January 20, 1904.

Alumino-Thermics, or the Production of High Temperatures by Burning Aluminum.

By E. Stütz.

I sincerely thank the officers of the Franklin Institute for the kind reception and for the opportunity courteously given me of explaining to you some of the results of Dr. Hans Goldschmidt's remarkable discoveries in the creation of high temperatures by means of aluminum.

I think I may say that Dr. Goldschmidt would have greatly liked to have been able to address the members of this world-famous Institute, the more so as two facts connect this city with the subject of my lecture. The one that your distinguished secretary, Dr. Wahl, was among the first scientists to demonstrate the heat-producing qualities of aluminum; the other, that on this continent it was in your city where Dr. Goldschmidt's process was successfully ap-

plied some time before its importance was more generally recognized.

I began by stating that it was aluminum that produced the high temperatures, some of the effects of which will be demonstrated to you presently. But not aluminum alone ; it required to be brought into intimate contact with the commonest of the elements on this planet, oxygen. By producing in a suitable manner the combination of these two, Dr. Goldschmidt obtained a temperature equal to that of the electric arc light. That is the starting point of the new science, christened in this country—I believe by Dr. Roeber—"alumino-thermics." The suitable manner of combining the two elements consists in *not* taking the atmospheric oxygen, but the solid one contained in the oxides and mixing these with finely granulated or pulverized aluminum. The resulting mixtures are the heat producers and are now known by the name of "thermit."

The first important discovery in observing the properties of these mixtures was that, when ignited in one spot, the combustion continued throughout the whole mass without any supply of heat from outside. The thermit is placed in crucibles which are not in contact with any external source of heat, and the combustion once started, embraces the whole mass in a very short time. This is the essence of alumino-thermics.

The thermit mostly used is iron thermit, in appearance a grayish-black powder. This is ignited by applying a storm match to a small pinch of ignition powder placed well in the middle of the surface of the thermit. The reaction is started at once, proceeds quickly and steadily, and is finished—whatever the quantity used—in less than a minute.

EXPERIMENT I. IGNITING THERMIT.

In the crucible after the reaction there are two layers. The bottom one is pure metal of equal weight to, but occupying only one-third of the space of the top layer, which is now oxide of aluminum, so-called corundum.

These two layers whilst still liquid are poured rapidly over the lip of the crucible. It is not difficult to distinguish

between the slag which flows first and the brightly glittering overheated metal.

EXPERIMENT II. POURING THERMIT.

I think the metal looks hot enough, but to demonstrate better than by mere figures what this heat means, I will now burn a hole through a 1-inch wrought-iron plate. The heat is computed to be about $5,400^{\circ}$ F. ($3,000^{\circ}$ C.).

You will notice that in this case the crucible is tapped from the bottom so as to allow the pure iron to run out first. The hole is perfectly smooth-edged; the heat is so concentrated that the plate is still cold after the reaction.

EXPERIMENT III. BURNING HOLE THROUGH PLATE.

To arrive at such efficiency has required patient study and assiduous work. Each of the various thermit mixtures, although made according to simple chemical rules, required studying out by itself. The formulas for gunpowder or dynamite sound fairly simple, but it requires more than a mere mixture of the ingredients to obtain any effect sufficient for industrial requirements. Not as if thermit were an explosive—you can throw it into the kitchen fire and it won't burn.

In the following I am going to illustrate by practical demonstration a *few* of the applications of the thermit process; to give an account of the entire field of its utility would go beyond the scope of a single lecture.

The applications may be roughly divided into two main divisions, the one concerning the metallurgist, the other the engineer. The latter application may be summarized in the word "welding."

Among the *pure metals* produced by the alumino-genetic reaction, I may mention in the first instance chromium free of carbon, as having already found a market in this country. It is used in the manufacture of particular qualities of chromium steel, with a limited percentage of carbon. For instance, it is considerably used for self-hardening tool steel.

Pure manganese also produced by this process finds employment in copper and nickel manufacture and, furthermore,

in the production of particular sorts of manganese steel of great strength and great elasticity.

There are a number of other rare metals important to the maker of high-grade steel, and to the metallurgist, produced by this process free from carbon, with an enumeration of which I need not trouble you. I shall just show you the nickel thermit reaction.

Although the demonstration is only on a very small scale, it will prove that the process is an extremely simple and expeditious one. In actual manufacturing, several hundred weight are produced in one reaction. At the end of the lecture the mass will have cooled sufficiently to enable me to show the regulus of pure nickel. The slag covering this regulus, particularly in making chromium, is utilized as an artificial emery on account of its great hardness. It has been given the name of corubin. It has also considerable refractory properties which have been utilized in various ways.

EXPERIMENT IV.

The part of the process which has received the widest attention and practical application is the Thermit Welding Process.

Considering the innumerable details connected with the application of so new and practically unknown a force, it is not surprising that only since about a year ago the process has been introduced on a large and commercial scale.

The most important of these welding processes is the one by which a continuous rail—a necessity of modern trolley road construction—is simply, cheaply and effectively obtained. Engineers in this country, in which over 25,000 miles of single track are in existence, are watching the good results obtained in Europe with this system. European authorities recognize its advantages over all its competitors, about 20,000 joints having been welded by this process since about a year ago in forty cities of the Old World.

I may be permitted to explain that, with rails embedded in the streets, exposing only a small surface to the direct influence of change in temperature, the contraction and

expansion are counterbalanced by the friction against the pavement.

The city of Leeds, in England, after careful investigation by a committee of experts, is using this process over the whole of its tracks, and an American expert, who had occasion to see it employed there, on his own initiative, recommended it for a very important contract at Singapore, where, in consequence, it is being used over a track of 27 miles.

The marked advantage enjoyed by this system is the absence of any bulky equipment; a crucible, a mold box and, in some instances where a complete butt-weld of the head of the rail is desired, a rail-clamp is all that is required. All these materials, including the necessary quantity of thermit, can easily be moved on a hand-truck. Each weld, according to section, requires from 15 to 20 pounds of thermit, and the metal welded around the joint will only weigh, therefore, from 7 to 10 pounds.

Even where a rail-clamp is used, the time employed is less than that necessary for fixing fish-plates and copper-bonds.

The mold is made according to a model designed specially for each section. Its two parts, one on each side, firmly enclose and exactly fit the rail. They are made on a large scale by manufacturers of refractory earthenware, or, according to the requirements of the trolley lines, in the repair shops, by tamping an ordinary mixture of china clay and sand into a sheet-iron case placed over the model, which has afterwards to be dried. The cost is only a few cents.

The thermit iron running out of the crucible flows round the web and foot of the rail, and, melting them, forms one mass with them. The liquid slag, which follows the metal, is diverted to the top of the rail and brings the latter to welding heat. The whole section is thus heated equally and the rail ends will not buckle.

The weld can be made with or without rail-clamps. By using the rail-clamps, a perfect butt-weld, without even the smallest slit, is obtained; the slight and very short upset can be easily removed. The rigidity of the joint is particularly great. Under hydraulic pressure the break occurs

outside the welded zone, as with the iron shoe welded on to the section, the joint is really stronger than the rail.

The use of the rail-clamps is, however, by no means obligatory. Without them the work is still further simplified, as the time necessary for adjusting the heavy clamps and for chiseling off the upset is saved. By practical experience, it has been found that the weld without clamps is quite sufficient. Of late the clamps are being used less and less, their use being based chiefly on theoretical considerations. Even a butt-weld can be obtained without clamps, particularly with rails already embedded. At Barmen, Germany, such work was done very successfully about a year and a half ago. The old fish-plates were taken off, the ends of the rails were raised slightly by means of a crowbar and a shim firmly wedged in between; in this case the shim is welded into the head of the rail.

Without clamps a joint takes three-quarters of an hour for one man; trained squads of four men, including foreman, did not use nearly so much time. At \$1.50 per day, the wages item of cost is 10 cents per joint. The use of the clamp doubles this amount. All other labor connected with welding remains the same whether clamps are used or not.

The mold, which must be dry and porous, is screwed on to the rail and the rims touching the rail are carefully smeared with clay. Before doing so, however, the rail ends are cleaned of dirt and rust with a wire brush and slightly warmed; a sand-blast is superfluous.

In case the tops of the rails are to be butt-welded, the section has to be filed.

This is all that is required in the way of preparatory work. A true alignment of the rail is, of course, an indispensable precaution. The rails require no bolt holes, as no provisional fish-plates are necessary.

You will recognize that none of this work demands special training, and that, as in Europe, the trolley companies' men in this country will be easily able to do it. A certain amount of supervision is a matter of course.

The welding is done automatically and does not require the trained eye of an expert welder.

In case of wet weather, the protection of a few planks is desirable to prevent the mold and thermit getting wet.

The only remaining appliance necessary for thermit welding is the crucible. This consists of a sheet iron mantle lined with magnesia. It is of simple construction, the lining being introduced by tamping it round a cone which is suspended in the middle of the mantle. The bottom is formed by a hard magnesia stone provided with an exchangeable outlet, which will stand nine to ten runs. Crucibles will stand about twenty-five reactions, and the wear and tear will, therefore, amount to only a few cents per joint. The thermit is supplied in small bags containing the exact weight which is needed to effect the weld. These are called welding portions and are sold as such to the trolley companies. The companies who make their own crucibles and molds, will, therefore, have to pay freight only on the welding portions, which is about one-tenth of that on fish-plates and bolts.

The works of Th. Goldschmidt, at Essen-Ruhr, Germany, who control the thermit patents, have a plant to supply over 500 welding portions daily.

I shall now show you how a rail is welded.

EXPERIMENT V. RAIL WELDING.

The strength of the weld is about 80 per cent. of the strength of the original material. The shoe welded onto the foot of the rail not only makes up for the remaining 20 per cent., but materially strengthens the rail at the joint. The head does not get softer, although it is brought to welding heat; the reason being that the operation takes place without the air having access to it. Test rods cut out of rails brought to welding heat with thermit, prove that tensile strength and elasticity have not suffered; a fact which is confirmed by three years' practical experience on the road.

Mr. Cole, the engineer in charge of the construction of the Singapore tramways, who, as I mentioned, is welding all his joints by the thermit process, writes as follows under date of October 10, 1903:

"We have not had one pull-apart, a thing that would occur very quickly if the weld was not all that was required, for we have large sections exposed to the weather for days *without being covered up*, and the contractive force of the changes of temperature would quickly pull the joints apart if they were not well done.

"The joints are nearly all done in the heat of the day, when the metal is expanded to its maximum limit. We have a difference of over 60° between night and day."

The strength of the thermit joint was tested under hydraulic pressure by Mr. F. S. McGregor, Permanent Way Engineer, Leeds City Tramways, and the results were published in the *Street Railway Journal* of November 13th last.

The so-called third rail is also welded by these means. The skin resistance of copper bonds increases with time, and frequent repairs are necessitated thereby. Welding obviates these repairs. It can be done in two ways. The first is identical with the one described before (but without the use of clamps), and is now in operation on 20 miles of the Metropolitan Underground Road, at Paris, France, where a short track gave satisfaction after a year's trial. The second consists in welding a small bridge of thermit iron between the feet on one side of the rail. Both are in use on a large scale; on the suburban road from Berlin to Grosslichterfelde, the Union Electricitäts-Gesellschaft, of Berlin, has welded 13½ miles of track. The rails on this track are exposed, three lengths are welded to one of 45 yards, which is connected to the next by a flexible bond. The other side of the joint, where there is no thermit-welded bridge, is mechanically strengthened by an ordinary light fish-plate. Just as well as 45 yards, much greater lengths might be welded. In this case the crucible is superfluous. The welding portion of about 3 pounds only is placed directly into the upper part of the mold, which is prolonged by a piece of gas pipe.

EXPERIMENT VI. WELDING THIRD RAIL.

It takes less time, as you see, to perform the experiment than to describe it.

The question of the continuous rail with exposed T-rails on railroads is not solved at present for want of sufficient tests. Of course, welding is the only means by which continuous rail properly speaking can be obtained with exposed rails. That it is practicable within certain limits and that it is desirable to have greater lengths of exposed track welded together, is admitted by permanent way engineers. The question is being investigated at present, but some time must elapse before a definite opinion can be arrived at. In any case exposed rails can undoubtedly be welded without any risk in tunnels and subways where differences of temperature are very slight and contraction and expansion therefore only minimal.

Steel girders for construction work can, of course, be welded in just the same way as rails. For really solid jointing equal to the strength of the girder itself, welding is necessarily cheaper than riveting. Some work of this kind has already been done in Germany, but in Europe there are none of the wonderful steel girder constructions which so greatly impress the European on his arrival in this country. There will be a wide field for this work in the United States as soon as the preparatory experiments and calculations have been made and officially sanctioned. After the experiment you have seen here, you will acknowledge the immense saving of time in using the welding process as compared to riveting.

This brings me to the next important application, or rather class of applications, the repair of solid iron and steel objects, a subject full of interest to by far the most numerous, although not the largest consumers of thermit.

The result of the reaction in the crucible is, as you know, a liquid iron, which sinks to the bottom, and an alumina slag that swims on the top.

Whoever has a supply of thermit and ignition powder has a supply of liquid mild steel, which on account of its low contents of carbon, 0.1 per cent., is very malleable and ductile. A man going to the North Pole, if he has a crucible, thermit, ignition powder and a match, can make steel right there.

We need not, however, go to the arctic regions to find useful employment for thermit steel. Whoever has a foundry can correct faulty castings, machinery shops can mend broken or worn-out parts, and last, but not least, marine engineering works can repair large steel castings, such as crank shafts, and particularly broken stern posts.

Wherever the distance from a construction shop is a matter of consideration, and in all outlying districts this thermit is of particular value. Within the last few months regular ton orders have been received from South Africa, where damaged machinery of all kinds has been repaired by it in the mining districts. In many cases cast iron has been welded, the liquid thermit steel being assimilated to the nature of cast iron by an addition of about 1 per cent. silicon in the form of powdered ferro-silicon with 12 to 14 per cent. silicon. This is thrown into the crucible as soon as the reaction is finished and a little time allowed before tapping.

Certain rules have to be observed in all repair work. First and foremost, the slag should not be allowed to get mixed up in the plastic iron. An appropriate position of the runner and a little experience in the construction of the most effective shape of molds will prevent this. The molds must be made so as to allow the liquid iron which runs out of the crucible to flow freely round the flaw or fracture, and to rise in the rising pipe. The latter must be large enough to hold sufficient metal, that the walls of the flaw, etc., are fused. The weld can either be effected by running the thermit iron round the ends of the piece in the shape of a ring, or by both running it between and round at the same time. The size of molds and quality of thermit necessary for welding shafts up to 300 millimeter diameter have been tabulated. A 12-inch diameter takes 190 pounds of thermit, giving 95 pounds of mild steel. These sketches will show some of the various shapes of molds.

The quality of the thermit steel may be adapted to various requirements by mixing small clean iron punchings into the thermit powder. For 10 pounds or more an admixture of 5 to 8 per cent., and for over 50 pounds up to 15 per cent.

of punchings will not make the overheated steel lose the property of melting and fusing with the metal it comes in contact with. This addition will, of course, raise the carbon percentage, a result likewise obtainable by an addition of ferro-silicon. An addition of $\frac{1}{2}$ per cent. of pure manganese free from carbon will also be found useful in many cases.

Steel can be welded on to wrought iron or cast iron, and *vice versa*.

It would be utterly impossible to give advice about the practicability of all or every sort of repairs that it might be desirable to make. The number is legion. All that we can do is to lay down general rules and supply the thermit.

The most startling, and at the same time the most effective, work done in the way of repairs by thermit is in connection with marine engineering. To weld broken stern posts of big transatlantic liners, or crank shafts, or similar pieces, crucibles of 6 feet in height, with a capacity of seven hundred weight, have been constructed. The reaction in these hardly takes longer than in a small crucible. The enormous advantage offered to steamship owners by such repairs will be apparent when it is remembered that a broken stern post would otherwise have to be replaced by a new one. Besides this expense the one incurred through loss of time, the steamer being laid up in dry dock for weeks and weeks, in order to have the new part fitted in, is very heavy indeed.

EXPERIMENT VII. WELDING THERMIT IRON ON STEEL PLATE.

I now come to an application of thermit which differs materially from those I thus far had the privilege of demonstrating to you. That is welding wrought-iron pipes.

Of course, the heat of the iron, if directly applied, would destroy the thin walls of the pipe. Here, then, the corundum slag created on the top of the mass in the crucible comes into play. On being poured it has the properties of adhering instantaneously in a thin layer to any object that it comes in contact with, and of being impervious to liquid thermit iron.

The *modus operandi* is, therefore, changed in some essen-

tial particulars. The reaction takes place in a crucible with a solid bottom, a small quantity of thermit only is ignited at first, and to this more is added as the mass subsides, and finally the contents are poured over the lip of the crucible in order to direct the slag, and not the iron, upon the thin walls of the pipe.

To butt-weld the pipes the ends must be made to fit accurately upon each other, and must be made bright with a file or emery paper. The two pipes are then firmly pressed together by the clamping apparatus, and the sheet-iron mold, well surrounded with moist sand, is attached. Welding temperature will be reached within a minute or two after pouring. The clamps then want tightening; one turn of the screw, and the weld is completed. The mold box is removed almost at once, and can be used several times. The surrounding mass, containing the iron between the layers of slag, like the yolk in the white of an egg, is easily removed with a hammer. Such welds will stand pressure of hundreds of atmospheres, as a matter of fact, as much as the pipe itself. About 30,000 to 40,000 pipe joints have been welded by this method, the advantages of which are shortly, that the operation can take place anywhere *in situ*, and that it is cheaper than a solid flanged joint. The dimensions of the mold have been carefully worked out and tabulated for every size of wrought-iron pipe up to 6 inches diameter. Any workman will be able to make such welds after very short practice, by carefully observing the few rules and directions printed in the pamphlets.

EXPERIMENT VIII. PIPE WELDING.

The numerous other applications of thermit for welding it would take too long to discuss in detail now. But apart from welding there is one large field for which aluminothermics may be of enormous importance. I am referring to foundry practice.

Professor Matthesius, one of Dr. Goldschmidt's associates, has especially devoted himself to studies concerning the improvement of iron and steel castings. These are obtained by introducing the thermit below the surface of the

bath, and so producing a high temperature in one place. A box containing the thermit is fastened to an iron rod and held down on the bottom of the ladle.

For cast iron, and in some cases for steel, a special thermit is used, which gives off an alloy of iron with titanium, so that the titanium enters the liquid metal. The reaction takes place all through the contents of the ladle and thoroughly stirs them up in the space of a minute or two. Gases or particles of slag are driven upwards, so that the fluidity of the iron is increased. An increase of the temperature does not in reality take place, as the proportion of added thermit is only $\frac{1}{4}$ to $\frac{1}{16}$ per cent. of the total contents of the ladle. The effect of the titanium is to bind small quantities of nitrogen, to increase the fluidity of the cast iron and to produce a finer grain.

Another application of the so-called "box reaction" is important for steel castings, and especially for casting large steel ingots, to prevent the familiar phenomenon of piping. In the heads of such blocks hollow spaces are found which mostly cause 30 to 40 per cent. of loss.

The thermit process as used for this purpose consists in introducing a box of so-called anti-piping thermit into a block with the aid of an iron rod, in exactly the same way as described before. According to the size of the block the box is suspended about 3 feet. The reaction is completed in this case in a few seconds. The box is introduced, of course, only after the piping has been formed. The head layer, which has already become solid, is broken through for this purpose. Immediately after the reaction is completed, steel, which is held in readiness for this purpose, is poured into the open hole. Only about 10 pounds of thermit are required for blocks of 10 to 20 tons weight. After the treatment relatively very small flaws were found and only in the upper part of the block, so that the loss is only a very few per cent.

The method has also been applied for very large steel castings to revive steel which has become plastic in the runners. In these the anti-piping thermit is placed at the bottom of some risers, in an annular box with concentric

walls containing about $2\frac{1}{2}$ pounds of thermit. There is in this case no need to thrust the box in by means of an iron rod. The piping will not protrude into the piece, but will be kept right at the head of the riser.

The difficult operation of casting long stern posts of vessels can be facilitated by inserting in several places boxes of this thermit. On account of the long way the steel has to travel, it has a tendency to grow plastic, but coming into contact with thermit, its temperature and thereby its fluidity are revived.

Before concluding I will show you a few lantern slide pictures from photographs of actual work done in all parts of the Old World and then the welds will be opened out for your inspection.

FIRST IRON CASTING IN THE UNITED STATES.

What is believed to be the first iron casting made in the territory now included in the United States, is preserved in Lynn, Mass. Its history is well authenticated. It is a cooking pot, weighing a little over 2 pounds. It was made about 1642, near Lynn, where a small blast furnace was built in that year. This furnace used charcoal for fuel, with bog ore found in the meadows along the Saugus river, and oyster shells as flux. The furnace was operated until 1688, with some intermissions.—*Engineering and Mining Journal*.

PROGRESSIVE TOWN IN NORTHERN CHINA.

It is not to Northern China that one would usually look for an example of electrical progress, but there is at least one place on the Eastern shore of the Liaotung Peninsula which might well set an example to many of the Western towns. We refer to the city of Dalny, which lies near Port Arthur in that portion of the Chinese Empire which was leased to Russia in 1898. Electrically, Dalny is up-to-date. The central station, which is considered the finest electric plant in Asia east of Singapore, was finished over a year ago. It is equipped with three of Ganz & Co.'s generators, with a total of 1,000 horse-power, and has a reserve space for additional machines to double its present capacity when required. Dalny, besides other things, is an important seaport, and has a drydock 380 feet long, 50 feet wide and 18 feet deep, which is equipped throughout with electric pumps. A larger drydock is building, at which electricity will also be adopted. In connection with the drydock are the harbor and repair shops, with foundry, smithy, machine and fitting shop, boiler shop, etc. All these shops are electrically driven and lighted throughout. Dalny also boasts an excellent telephone service, and altogether it may fairly claim to be one of the most progressive cities in the East.—*Electrical World*.

CHEMICAL SECTION.

Stated Meeting, held March 17, 1904.

Concerning Soils, Germs and Worms.*

BY DR. PERSIFOR FRAZER.

In Part III of the Report of the Geology of New Jersey, of 1868, under the head of "Economic Geology," the Director, Prof. Geo. H. Cook, says: "In the detailed geology and under the proper heads, will be found chemical analyses of gneiss, limestone, slate, shale, trap rock, clay, green sand, etc. The soils are mostly derived from these; sometimes from one, and sometimes from a mixture of two or more of them. And this geological classification is the best that can be made. A more common classification is into sandy, loamy and clayey soils. The latter, however, is not capable of general use. The meaning of the terms always depends on the experience of the person who uses them. What in one part of the State is called a clayey soil, in another part is called a loamy soil, and in still other places it would be called sandy," etc., etc. This statement will furnish an appropriate introduction to the observations on soils which are here proposed, since it shows how vague is the average conception of the character of that storehouse whence we draw our life. But the farmer's division into sandy, loamy, and clayey is not more crude than was that of the average geologist. To him soils were but the comminuted rocks of the earth's crust mixed with more or less adventitious organic matter, and moistened by the rain, the dew, and the capillary flow of the ground waters. Professor Cook, as he says, "to show how light or sandy a soil will produce vegetation," instances in the same chapter the following analysis of beach sand from Old Beach, Atlantic City:

* Substance of a lecture delivered before the Pennsylvania Horticultural Society, Tuesday, April 18, 1899, by Dr. Persifor Frazer, Professor of Horticultural Chemistry, Penna. Hort. Soc. Subsequently revised to January 1, 1904, and in part rewritten.

Silicic acid and quartz	95'44
Alumina	} 3'00
Peroxide of iron	
Lime	0'45
Magnesia	0'22
Water	0'30
Total	99'41

In the report of the geological survey of New Jersey for 1879, glass sand and sandy clays are noted as producing oak-land and pine-land soils.

How very different is the idea of a soil in the minds of the agricultural chemists of the present day may be judged by Wiley's definition ("Principles and Practice of Agricultural Analysis." Chemical Pub. Co., Easton, Pa., 1894): "The term soil, in its broadest sense, is used to designate that portion of the surface of the earth which has resulted from the disintegration of rocks and the decay of plants and animals, and which is suited, under proper conditions of moisture and temperature, to the growth of plants. It consists, therefore, chiefly of mineral substances, together with some products of organic life, and of certain living organisms, whose activity may influence vegetable growth either favorably or otherwise. The soil holds various quantities of gaseous matter and of water, which are important factors in its functions." Yet it is possible to make plants grow without the intervention of any soil in the sense of the last definition (Storer, "Agriculture in Some of Its Relations with Chemistry"); for not only does the mistletoe grow in the air, but hyacinths, cuttings of rose bushes, *tradescantia*, and Indian corn, or almost any of the ordinary grains, may be made to grow and bear seeds in glasses of water, provided the latter contain some ash-producing material and some nitrates, which are ordinarily derived from the soil. However small the amount, some potash, lime, magnesia, iron, phosphoric, sulphuric and nitric acid (or, in the place of the last, ammonia) must be present in order to develop the plants of the higher orders (id. I).

Soil is necessary as a prop for the plant in nature, as well as a sponge from which to extract the food which is to sus-

tain it; and for certain plants, such as tubers, the light, easily-displaced covering of pure silica sand, when once well manured, produces more perfectly formed plants than the less yielding natural mold.

The passage of water and its saline constituents through a plant, and the evaporation of the former (or, more properly, its exhalation, since the process is connected with the life of the plant and may take place, unlike ordinary evaporation, when the surrounding atmosphere is saturated with moisture), results in an enormous circulation, estimated by Watson at 30 hogsheads of water on every acre of grass land per day. About 300 parts, by weight, of water pass through a plant to one part fixed and assimilated in its tissues.

Ordinary soils contain large quantities of nitrogen; in fact, by a series of experiments on Scotch soils and manures made by Anderson, the average proportion of organic matter in the soils was 7.02, and of nitrogen in this organic matter 0.206; or a relative proportion of nitrogen to organic matter in the natural soil of somewhere near 1 : 35; whereas in the manures applied to the eight farms from which these various soils were taken, the average proportion of organic matter was 13.94, and of nitrogen 0.382. The proportion of the nitrogen to the organic matter in the manures was as 1 : 36.49. Consequently, the relative proportion of this invaluable plant food element was higher in the natural soil than in the manure laid on to enrich it.* Professor Storer con-

* It is interesting in this connection to note the "fertilizing ingredients" and their cost, enumerated by Mr. MacFarlane in his admirable report on "Fertilizers." The quantity of each ingredient in a given fertilizer must, according to Dominion law, be stated by the dealer. (Published by the Inland Revenue Department of Canada, Bulletin 86, Ottawa, 1903.)

Nitrogen in salts of ammonia or nitrates as well as in com-	
pound fertilizers	\$0 13
Organic nitrogen in ground bone, fish, blood or tankage . . .	12
Phosphoric acid—soluble in water	6
“ “ “ 1 per cent. citric acid	5½
“ “ insoluble in Thomas' phosphate powder . .	3½
“ “ “ ground rock phosphate and	
fertilizers generally	1½
Potash contained in wood ashes	6
“ from high-grade salts	5¼

siders the utilization of these natural and almost inexhaustible supplies of nitrogen among the most important of the problems of to-day, and adds that from remote time the improvement of the soil-nitrogen has been deemed, by wise cultivators, more advantageous than employing fertilizers, or keeping additional cattle to produce more manure. These stores of nitrogen are found in arable loam, leaf mold, peat, swamp and marsh mud, etc., and here is where an agent often neglected renders valuable service, as will be seen further on.

The effect of "symbiosis," as Storer calls it, or blended life of various kinds, is well illustrated by the little knobs and warts on the roots of clover and leguminous plants. The most generally received explanation of this phenomenon now is that bacteria enter the roots from the soil, and form colonies within the roots, thus giving rise, by the mutual growth of bacteria and plant-cells, to those excrescences. The lower organisms thrive on the juices of the plant, and in turn render some service in supplying these roots with nitrogen. Hellriegel has shown that nitrogen from the air is stored up for the benefit of such plants, even when the latter are grown in sand free from organic or nitrogenous matter. Nodules form upon the roots at the time that nitrogen is being taken from the air; but material akin to the ash-residue of the normal plant must be strewn with the sand. When growth ceased, in such experiments, occasionally germs from the air fell upon the sand and started the growth anew; but on supplying water, which had been in contact with garden loam and was charged with bacteria, the full and healthy growth was recommenced, and the plants assumed their normal dark-green color. The plants feed upon the substance of the bacteria after the latter have died.

These plants, which get nitrogen from the bacteria, charge the soil with nitrogen to the benefit of succeeding crops of other plants; and this is the modern explanation of the utility of rotation in crops, which has been recognized probably ever since husbandry began. A continuous succession of peas, for example, not only gives rise to nematode

worms, instead of bacteria nodules on the pea roots, but these worms are transferred to the next crop which is put in, and impair or ruin it.

Great lichens, such as reindeer moss, or Iceland moss, grow freely on bare rocks and sterile soils. Fungoid growths are noticed, even covering in a few days surfaces of iron. These fungi produce large quantities of nitrogenous organic matter.

Berthelot showed that certain nitro-organisms living in soil feed on the nitrogen of the air, and produce nitrogen compounds, at first insoluble in water, but later converted into soluble nitrates, to the amount of 75 to 100 pounds per acre per annum.

But the fixation of nitrogen by nitro-organisms in the soil is less important than that by bacteria on the roots of leguminous plants.

The general conclusions as to nitrogen and micro-organisms in their relations to plants, reached through the work of Atwater, Wagner, Heiden, Hellriegel and Wood (of the Storrs Agricultural School in Connecticut), may be thus summarized :

Pease, alfalfa, serradella, lupine, probably clover, and in general all leguminous plants acquire large quantities of nitrogen from the *free nitrogen* of the air during growth.

It is clear that there is a connection between the root tubercles and this acquisition of nitrogen, but what the connection is remains to be discovered.

Cereals which have been experimented with have not shown this power of taking nitrogen, nor had they such tubercles as are found on the roots of legumes.

In the experiments undertaken soil infusions did not seem necessary for the production of root tubercles. It is considered probable that the micro-organisms or spores were floating in the air and thence found their way to the pots in which the plants were growing.

As a rule in the experiments, the greater the abundance of root tubercles, the larger and more vigorous the plants, and the greater the gain of nitrogen from the air.

Where loss of nitrogen occurred there were no root

tubercles. It was largest with oat plants and largest where they had most nitrogen at their disposal in the form of nitrates. The gain of nitrogen in legumes helps explain why they act as renovating crops, and the loss in the case of oats suggests why they should be an exhausting crop.

(MacFarlane, Bulletin 86. Canadian Report I. R. D.)

On barren ledges of rocks the frost and other causes produce disintegration, and the spores of fungi resting on this talus produce nitrogenous matters from the air. The soil is then ready for the next step, which is the making of mold.

Humus, according to Storer, is the organic portion of all the earth-like products which results from the decay of vegetable or animal matters. In temperate climates the tender parts of vegetable matter are converted by the oxygen present into carbon dioxide and water (through micro-organisms chiefly), and the residue is humus, which resists further decay.

The acids of various constitution, together known as humic acid, though not very soluble in water, are chemically active.

Agricultural plants, in general, cannot feed directly upon humus, but, through the micro-organisms which feed on it, are supplied with nitrogen.

Three ferments in all are needed: one to set free ammonia; one to produce nitrites from it; and one to produce nitrates from nitrites. Nitrification is most active in hot summer weather. No nitrates are produced by putrefying processes. On the contrary, nitrates, if present, are converted into ammonia.

In an experiment made by Leone with nitrates and dung in loam, placed in a box so that air could freely pass between the particles, first nitrates were partially reduced to nitrites. In a fortnight both nitrates and nitrites disappeared, and only ammonia was detected. In little over a month, nitrates again began to appear, and in three months there were only nitrates. Lorgna defines nitrification as the last term of putrefaction.

The above experiment shows how easily an injudicious

treatment of a valuable manure may entirely destroy its efficiency. A few words on the value of farm manure and the best methods of securing, preserving, increasing its efficacy, and applying it, seem here appropriate. Hellriegel, in 1897, proposed a simple plan easily applicable everywhere and every year, by means of which a practical agriculturist may see differences between adjacent crops treated differently, and thus decide what should be the substance applied to the soil to insure the best harvest. It is to pass over a few square rods of the field, at various places properly selected, without applying dung or fertilizer. In accordance with this principle other plots of like dimensions may be treated respectively with lime, marl, dung, or fertilizers. The heights and densities of the resulting crops, the fulness of the ears and the development of the grains, etc., may easily be compared, and a correct conclusion drawn as to what is best for that particular soil.

J. Koenig, in his prize essay, "How Can the Farmer Preserve and Increase the Stock of Nitrogen on His Property?" (Berlin, 1887), gives the results of his investigations and experience as follows :

(1) In the decomposition of nitrogenous substances of every nature a loss of free nitrogen, more or less considerable, takes place.

(2) This loss is the greater the more the atmosphere has access to the decomposing mass.

(3) Too much moisture is as hurtful as too little. Stable manure requires such a degree of humidity as permits its components to lie close together.

(4) The addition of substances which fix ammonia (such as gypsum, kainite, and kieserite) prevents or reduces the loss of nitrogen. *These substances are, however, of little or no value if care be not taken at the same time to prevent as much as possible the access of air.*

In storing stable manure, it should be kept in a water-tight receptacle, roofed in, and it is desirable that it be trodden down by the farm animals. It is perfectly clear that the use of gypsum or ordinary ground land plaster prevents any loss of nitrogen in the stable, and, according to

Holdefleiss, Vogel, and others, the same substance, or gypsum produced in the manufacture of the acid phosphate, prevents the loss of ammonia from the liquid part of the manure. Another suggestion by Dr. C. A. Goessmann, Chemist for the Massachusetts Agricultural College (Bulletin 45, March, 1897), is that there should be added to the manurial refuse materials of the farm such single manurial substances as will enrich the former in the directions desirable for any particular crop.

(Canadian Inland Revenue Department Bulletin, No. 86, before cited.)

The substance of the following notes on bacteria is taken from an interesting lecture entitled "The Analysis of Water, Chemical, Microscopical and Bacteriological," before the Lowell Institute, Boston, December 5, 1889, by Dr. Thomas M. Drown, then Professor of Analytical Chemistry in the Massachusetts Institute of Technology, now President of Lehigh University, Pennsylvania. In speaking of the bacteria found in the sanitary analysis of potable waters, he says: The bacteria belong to the lowest form of life; a simple cell, with wall and contents, capable of self-nourishment and reproduction. Until within a few years their presence was unknown and unsuspected, so minute are they, and yet their importance in the economy of nature is such that higher life would come to an end if their activities were to cease. It is unfortunate that these ever-present, humble, useful organisms should be associated in our minds mainly with evil purpose and effect. True, there are malignant bacteria, to which we cannot assign any beneficial role in nature; but so there are poisonous fruits.

The bacteria, or germs, as they are also called, have many shapes; the ball or egg-like forms include the genera micrococcus and streptococcus; the rod-like forms, the genus bacillus; and spiral forms, the genus spirillum. A special form of bacteria we have all become familiar with in name--the cholera germ, called by Koch the comma bacillus.

The function of the green plant is to make organic material out of the inorganic. Trees, grass, and vegetables

live entirely on the carbonic acid of the air and the water and mineral matters in the soil. Animals cannot do this, but require either vegetable or animal food. In utilizing this food, the animals do not reconvert it all into mineral matter again. The nitrogen in the proteid, or albuminoid matter which they consume, is not excreted in the oxidized form of nitrates, but as urea, a compound related to ammonia. Then the bacteria step in, find food for their support in the waste which has no more value for animal life, and complete its conversion into mineral matter that it may again serve as food for plants.

The method employed to determine the numbers of bacteria is based on the principle that by stimulating their growth and making them increase enormously within a small space, in which they cannot move, the aggregations of the newly developed bacteria will be so large that they can be seen by the naked eye. This ingenious suggestion was carried out by the famous bacteriologist, Koch, in this way: A small quantity, usually 1 cubic centimeter, of the water (that is, about one-fifth of a teaspoonful) is mixed thoroughly with, say, ten times its amount of a sterilized solution of gelatine, which contains extract of beef, peptone, etc., to make it highly nutrient, and the mixture is poured, while warm, upon a glass plate, so that it forms a thin layer when solidified. This is set aside for a few days in a warm room under a cover, and protected from the germs in the air. If bacteria are present in the water they will grow with great rapidity under these conditions, each bacterium forming a colony, as it is termed, of thousands or millions of bacteria. Then we can see and count them. It is assumed that each colony arose from a single bacterium in the water; hence, by counting the number of colonies on a plate, we arrive at a determination of the number of bacteria in the cubic centimeter of water used.

The numbers of bacteria, as determined in this way in natural waters, vary greatly. A water taken directly from the ground, at a depth of six feet or more, should contain none. In good pond waters may be found anywhere from a few score to a few hundred. In polluted streams they may

run up well into the thousands or hundred thousands, and in sewage they can be sometimes counted in the millions. Organic matter is composed of carbon, hydrogen, oxygen, and nitrogen; at least, for our purpose it will suffice if we so consider it. It is only the nitrogenous organic matters which undergo those kinds of changes which we include under putrefaction, and which we regard of importance from a sanitary standpoint. Familiar examples are milk and meat, which, when exposed to the air, become offensive, but starch and sugar (which contain no nitrogen) do not.

The nitrogen which we find on analysis from undecomposed animal and vegetable matter, say fresh albumen, we call "organic nitrogen," by which we mean that the nitrogen is still in its original combination before change or decay has set in. Leaving out of consideration that present in rain-water, we may say that ammonia in water is distinctly characteristic of the first stage of the decomposition of organic matter. The term "organic nitrogen" has been used, but on the tables of analyses another is substituted, namely, "albuminoid ammonia." It is an unfortunate fact that the methods of determining organic nitrogen have been, until recently, very tedious and difficult, and not always reliable, so that chemists have resorted to another process, which gives only a part of the organic nitrogen in the form of ammonia. That is called albuminoid ammonia, because albumen, when subjected to this process, gives up its nitrogen as ammonia.

From the present methods of examining water the following facts are ascertained. (1) By means of the microscope, the kind of life existing in the water, from which conclusions are drawn as to the kind and quality of the food which supports this life. (2) By means of the gelatine plate cultures, the number of the bacteria in the water, from which conclusions are drawn as to the amount and kind of decay going on. (3) The purely chemical examination reveals directly the amount of organic matter, and the conditions in which it exists. These widely different methods are merely different points of view. It is one and the same thing throughout, namely, the life processes which are

going on in the water; for decay is but the manifestation of another form of life.

If it is asked why study is centered here, the answer is, simply, that experience has taught that it is the organic matter which is the cause or accompaniment of disease; it is during the decomposition of this organic matter, and in some of the changes it undergoes in the process of decay, that danger lurks. This is the chemical expression of the causation of disease. The biological expression takes another form, namely, that the bacteria which cause changes in the organic matter cause also disease. The two expressions do not contradict each other, but go hand in hand. The chemical idea implied in both expressions is that the state of change is the state of danger. From an horticultural point of view, the state of change is the state of evolution.

The vegetable mold which forms the rich top-soil of every agricultural country consists of a very uniformly fine mass of blackish color, usually only a few inches in thickness, though under exceptionally favorable circumstances it may reach a depth of nine or ten inches. Humus (of which there is a surprising lack of definition in the best works, but which is generally understood to be earth more or less charged with decaying organic matter) is well illustrated by beds of peat and so-called muck. The latter term, however, according to Storer, is misapplied, and should mean "well-rotted dung" (II, 78), though in this country, and especially in New England, it is synonymous with marsh mud. The vegetable mold, if not coincident with, at least contains the greater part of the humus in a given area, and it is in this that the germination of seeds and the growth of plants have their best development.

The humus has been investigated by our countryman, Prof. A. A. Julien ("On the Geological Action of Humus Acids." *Pr. A. A. S.*, XXVIII, 1879, 311), by whose labors it is established that there are many acids of complicated constitution confounded under the name humic acid. All of them act energetically upon rocks, and perform important functions in the preparation of the material

with which they come into contact to facilitate plant growth, directly through the disintegration of leaves and animal tissue, and indirectly by furnishing food to the bacteria which are so indispensable to vegetable life.

Charles Darwin, among the countless contributions of this greatest of naturalists to our understanding of nature, has observed ("The Formation of Vegetable Mold through the Action of Worms," etc.; Appleton, 1882) that the upper part of the intestines of earth worms generates the several humus acids which are produced by decaying vegetation. The calciferous glands lying below this tract produce a material which neutralizes the acids thus generated, for the digestive fluid of worms will not act unless it be alkaline. These acids, he thinks, are generated during the digestive process, and are probably of nearly the same nature as the humus acids, so that the agency of worms in producing the material out of which that of plants is assimilated is evident. The action of worms is not confined to chemical changes, but extends in many widely different directions, and, according to this accurate observer, is stupendous in its results. At the risk of repeating what is familiar to many of you, I will sketch briefly this action as epitomized in the work just cited. There are but few genera of earth worms distributed throughout the world. Their mode of life is to burrow in the ground, which they do by eating a hole through the soil, and with the mouth filled, advancing the œsophagus, thus forcing the cheeks outward in all directions, crowding the soil aside, and enlarging the burrow. ("The Soil," etc., F. H. King, Professor Agricultural Physics in University of Wisconsin; Macmillan & Co., 1896.) The material swallowed is passed through the calciferous glands lying midway in the œsophagus, where the acids are neutralized; through the crop and gizzard, where the particles are trituated by the hard stones habitually retained there; and into the intestine, where the pulp is again made acid; whence, at the mouth of the burrow, it is voided in the form of castings or worm-dung in piles of greater or less size, and more or less retaining the mold of the intestines. The castings may be seen after a

rain, especially in gardens and much-frequented walks. Earth worms work preferably at night, and lie close to the mouths of their burrows by day. The mouth of a worm is situated at the anterior end of the body, and by means of a lip the animals can grasp an object and draw themselves forward. Their intestine has a deep involution of its walls, by which additional absorbent surface is gained. They breathe through the skin. They are destitute of eyes, but conscious of a bright light and sensitive to it in the anterior part of the body. They are less sensitive to radiant heat. They are very sensitive to touch or vibration, though not to sound. Their perception of odors is feeble, but enough to direct them to objects which they like to eat (cabbage leaves, onions, etc.).

They are omnivorous, swallowing everything they can grasp, and extracting what nutriment the mass contains. Their preference is for half-decayed leaves, however, which they draw into their burrows partly for food and partly to close the entrances; and to this circumstance is due much of the finest soil which they produce.

They moisten the objects with a secreted alkaline fluid like pancreatic juice. The calciferous glands are probably fed with lime by the leaves in which this earth concentrates before they fall. This is excreted as carbonate of lime and aids the digestive process. The castings of worms are usually acid. Darwin concludes that they possess a low order of intelligence, in contradistinction to instinct. His experiments on this subject are very curious and instructive. With worms kept in a pot he observed the manner in which hundreds of objects of different shapes were drawn into their burrows, which are thus lined, he thinks, on account of the sensitiveness of the animals to cold, for the purpose of avoiding the contact of their bodies with cold, damp earth. The amount of work performed by worms is measured by the rapidity with which objects laid on the ground become covered by their castings. There are instances of coal ashes, strewn over a large field, which were buried in this way 7 inches in eighteen years. The tesserae of pavements, ancient buildings, large stones (including some of

the Stonehenge), ancient walls, etc., are found to be covered to a greater or less depth by the castings of earth worms, and independently of the action of other agencies. With this, of course, is to be reckoned the sinking of these objects through undermining by worms, and the subsequent collapse of the burrows. The soft mold removed from lower levels to the surface has passed repeatedly through the intestines of worms, and much of it has been finely triturated in their gizzards. Darwin estimates that, in each acre of earth which is sufficiently damp and not too sandy, gravelly, or rocky for worms to inhabit, a weight of more than 10 tons of earth annually passes through their bodies and is brought to the surface. The result for a country of the size of Great Britain in, say, a million years, is 320 million million tons of earth in land which is cultivated and well fitted for these animals. It is probable, he thinks, that all of the finest vegetable mold which we see has passed again and again through the bodies of earth worms.

There is a series, and perhaps a cycle, of changes from the partially cooled, still incandescent mass, and newly formed planet—the Earth*—to the well-cultivated hive of industry of to-day; teeming with millions of workers prosecuting countless industries, all of which depend upon the

* A new view of the evolution of our planet eliminates incandescence and change from gas to liquid and from liquid to solid during the earth's history. [T. C. Chamberlin, *Journal of Geology*, vi, 609; vii, 545, 667, 752. H. Le Roy Fairchild, *Bul. Geol. Soc. Am.*, vol. xv.] According to the modern substitute hypothesis the discrete matter derived from the hot nebular ring was cooled before it aggregated to form the earth. But even if this new view should ultimately displace the assumption that the earth was a hot fluid ball, which so many distinguished geologists have considered the necessary consequence of La Place's Nebular Hypothesis, it will not in any way affect the proposition of the interdependence of various forms of life herein stated. Neither the old nor the new hypothesis of the origin of the earth pretends to account for the advent of life, and its dawn is almost universally ascribed to a time when the surface of the planet was not greatly warmer than it is now. The only difference is that the new theory gains the disposal of an immensely greater period of time during which this earliest life may have been evolved into the many forms existing to-day, and shakes itself clear of the fetters which Lord Kelvin and other physicists have put upon geological speculation. Professor Fairchild's plea is "Geology for the geologists!"

change of form of the materials which the earth furnishes, sometimes for the sake of these new forms, and sometimes for the sake of the forces which are incidentally generated; but all of which are made possible by the life which the earth gives to the workers through the products of its soil.

(1) There was the partially cooled, lava-like crust of the earth, glowing cherry-red, and surrounded by the heavy acid vapors and steam, wherein the volatilizable oxygen compounds of sulphur, phosphorus, nitrogen and the like, known as sulphuric, phosphoric, and nitric acids, pervaded and gave their acid character to the dense, inky clouds of steam mingled with all other but the most unvolatilizable terrestrial elements.

Finally, when additional cooling had taken place, these acid vapors condensed and descended in torrents which exoriated the vitreous mass, and sent floods of highly saturated solutions into its natural depressions—the first commencement of a sea. The waters heretofore enveloping this planet in clouds like those of Mercury and Venus, descended in great mass and deluged the basaltic crust, cracking and comminuting it, and thus offering the acids more favorable opportunities to attack and dissolve its substance; tearing away its salient prominences by crush of flood and gale; spreading out the debris as a slime, mud, or sand in the natural channels; and carrying the finest suspended particles into the sea. At last, the alkaline ingredients neutralized the acid waters, and the ocean contained only highly diluted neutral salts.

The contraction of the nucleus produced new elevations and depressions, changing the old ones; so that continuously the bottoms of the seas emerged and became dry land, and high ridges were depressed under the surface of the waters. Somewhere, either at this period or perhaps from the very beginning, appeared the force we call life because we cannot understand it; and in all probability its lowest known form—perhaps some sort of bacterium. The derivation from this simplest life-element of the lowest life-kingdom we recognize—that of plants—is not yet understood, but the advance accomplished, as always occurs in nature,

the plants assisted, and were assisted by their predecessor in form, until still further progress was made; each stepping-stone being used as a support to place the next, while the old were not destroyed; just as a man flings blocks into a stream to cross dry-footed, and stands on the last he has planted to place the next.

Then plant-growths imperceptibly changed in complexity and character to the second and highest life-kingdom—that of animals; but so insensibly, and with so many interlocking characteristics among the beings which are found on the border line, that no definition has yet been found which can quite satisfactorily indicate the distinction between animal and plant, nor between plant and mineral, nor between vital and any other kind of force.

Taking the sequence of events as they are, the infinite variety of plant and animal forms, from the minutest unit capable of being seen under the microscope to the gigantic California redwood, and the elephant, the lower forms and forces act as servants to the higher. The winds and frosts still tear new mineral matter apart, and the rivers and ocean grind, sift, and spread it into gently sloping prairies. The micro-organisms and the fungi invade this material, and, reaching to the atmosphere for the organic elements which it contains, translate this carbon and nitrogen into lichens, moss, herbs and humus. But with this advance in the vegetable world an advance in the animal world has taken place *pari passu*, and, amongst other useful forms, the worms appear as husbandmen and workers of this crude mass into soil fit for the highest plants. Again and again this comminuted dust, with its bacteria, goes through the alimentary canal of the worm, and is spread over the surface, hard or soft, sterile or fertile alike, hiding the floor of our planet under the rich banquet which these humble creatures spread out for higher forms of the lower kingdom.

Upon this spring the grasses and grains, the bushes and trees, which in turn send down their roots through the soil, and, saturating the unaltered crystalline rocks with their acids, prepare new material for the steps of preparation

which have been described. On the higher forms of plant life the highest forms of animals live, the highest as well as the lowest representatives supplementing their simpler diet by feeding on each other.

The processes are so various, the change of action so incessant, and in such endless rotation from purely physical or chemical to vegetable and animal, that one is unable either to specify in what resides the high and the low in nature, or wherein the forces or the forms we recognize in the three kingdoms differ from each other fundamentally, in spite of the superficial differences which appear to our senses.

THE INVENTOR OF THE DYNAMO.

Dr. H. Wilde has brought an action to restrain Prof. S. P. Thompson from referring, in books of which he is the author, to certain electrical machinery as being "dynamo-electric machinery," Dr. Wilde himself claiming the distinction of being the inventor of the dynamo and dynamo electric machinery, and objecting to the invention being accredited to any one but himself. The lower court and the appeal court decided in favor of Thompson. In the same impression of the London *Electrician* from which the foregoing is gleaned there is a long letter by S. P. Thompson on the definition of a dynamo. The word is used by authoritative writers in two different senses, either in the narrow sense of the self-exciting machine or in the wide sense, including all machines in which mechanical movement is used to generate an electric current, only the electrostatic class being excluded by common consent. On the other hand, what Dr. Wilde had in effect sought by his suit, was to force everybody to employ the term dynamo only for separately-excited machines.

GARBAGE DISPOSAL AND THE HARBOR CHANNELS.

A strong argument for the rational treatment of garbage accumulations of larger cities is contained in the following editorial comments of the *Scientific American* on the consequences of dumping the refuse of New York City in the waters outside of Sandy Hook.

The United States Government is engaged in dredging a great 40-foot channel from deep water off Sandy Hook to the Narrows within New York Harbor. If a 40-foot contour line were drawn on the chart, it would be found to extend across the harbor mouth well inside of Sandy Hook lightship; and when the channel is completed, incoming vessels of the largest size will be able to sail from deep water to the Narrows without any of the tortuous and difficult navigation which at present is a source of more or less anxiety to incoming vessels, especially if they happen to be of the draft and length of our largest trans-atlantic liners. Unfortunately, the success of the scheme is menaced by the fact that the waters outside of Sandy Hook are used as a

dumping ground for city refuse; and the enormous amount of refuse that is unloaded year by year from the city's scows would seem to be at last producing the disastrous results which have been feared by those who are interested in preserving unobstructed navigation into this harbor. A Sandy Hook pilot recently reported that in several places south-southwest and south-southeast from the lightship, and within a radius of $\frac{3}{4}$ of a mile, the cast of the lead showed only $7\frac{1}{2}$ fathoms where from $11\frac{1}{2}$ to 16 fathoms are called for by the chart. Here is a matter that demands the immediate attention of the Government. Seven and a half fathoms is within 5 feet of the depth to which the new channel is being dredged, and if this shoaling up is due to the dumping of city refuse it may be taken for granted that the formation of these shoals will be continuous. As matters now stand it looks as though we were undoing with one hand what we are doing with the other. In any case, the present method of garbage disposal is an extremely crude and provincial one for the metropolis of the western hemisphere. It is also distressingly "sloppy" and untidy. The neighboring shores of New Jersey give evidence of this, for they are adorned with a variegated fringe of domestic refuse and "cast-offs" that would do credit to the back alleys of a western mining camp.

RECLAIMING MARSHLAND.

A great deal of northern Minnesota is about as flat as a floor. Over a wide area east of the Red River Valley the water partings between the streams are scarcely perceptible. Many of the streams meander in tortuous courses sluggishly over the prairie and lose themselves finally in big marshes. Some of the rivers, as shown on the maps, appear suddenly to terminate just as rivers are marked on maps of deserts where the streams are lost in the sands.

According to the *New York Sun*, a number of these large marshes are not far from the Red River Valley. It is proposed to dig some long ditches to lead the waters of these now sodden and worthless lands into the valley. The Lost River ditch will be four miles long, and will drain 22,000 acres of swamps; the Badger ditch will be eight and a half miles long, draining 5,300 acres; the New Solum ditch will be four miles long, draining 1,000 acres; the Good-hope ditch, five miles in length, will also drain an important area.

The total cost of these four ditches is estimated at \$26,500, and they will turn 30,000 acres of swamp lands into the richest of fields and meadows, adding most appreciably to the productive area of the State, and improving the health conditions in that part of the country. The contractors have already begun the work on these important improvements.

TIN MINING IN SOUTH CAROLINA.

Outside of Alaska the only tin mining in the United States at present is found at Gaffney, in the northwestern part of South Carolina, near the North Carolina line. The first shipment, amounting to 20 tons, of tin ore from this Gaffney deposit has just been made by S. S. Ross, the ore going to England. This deposit is a continuation of that at King's Mountain, in North Carolina, which was opened fifteen years ago by Mr. Richard Eames, Jr., and which at that time produced some high-grade cassiterite.—*Engineering and Mining Journal*.

ELECTRICAL SECTION

Stated Meeting held Thursday, October 8, 1903.

Rail Bonds.

BY W. E. HARRINGTON.

General Manager Camden and Suburban Railway Company.

(Concluded from p. 230.)

SPECIAL RAIL-BONDING TOOLS.

Figs. 67 to 71 exhibit a series of special rail bonding tools designed for placing amalgamated bonds.

AJAX BOND.

The Ajax bond consists of a sheet or piece of copper, contacting with the web of rail on each side of joint under the fish plate or joint, held up and against the web by set screws, cupped hardened ends, set screws set in fish plate or joint; usual method is to insert a sheet of steel between copper plate and points of set screws. The web of rail having been ground off and treated with Edison-Brown alloys, as well as the side of the copper plate contacting with rail, the result is to all intents and purposes a knife-blade switch. In all cases where the Ajax bond has been installed and action and life observed, it has invariably shown a very satisfactory condition.

Test No. 11 shows 90 per cent. resistance, three years life.

It might be interesting here to mention other makes of bonds more or less in use, some of which have fallen into disuse, either from inefficiency or interested parties discontinuing manufacturing:

Johnston bond, West End bond, Bryan bond, Columbia bond, Channel Pin bond, Forest City bond, S. H. Harrington ball bond, S. H. Harrington diagonal bond, Grauten bond,

Stern & Silverman bond, Payne welded bond, Atkinson bond, Syracuse bond.

CAMDEN AND SUBURBAN RAILWAY BONDS.

The C. & S. bonds shown in *Fig. 73* were designed by the writer and intended to provide large, ample contacts. The



FIG. 67.—Portable grinder.

No. 1 C. & S. bond consists of a square copper casting with two grooves for 4/0 B. & S. gauge copper wire; casting has a $1\frac{1}{16}$ -inch hole in center. A cast-iron casting with corresponding grooves and hole is provided. The bond is

applied by grinding off the web of the rail with an emery grinder and treated with Edison-Brown alloys, serving to amalgamate the surface of the rail and fill valleys and depressions and irregularities of the surface, the 4/0 wires and the copper casting grooves are also treated, the whole is then bolted to the web of the rail with a 1-inch bolt, using

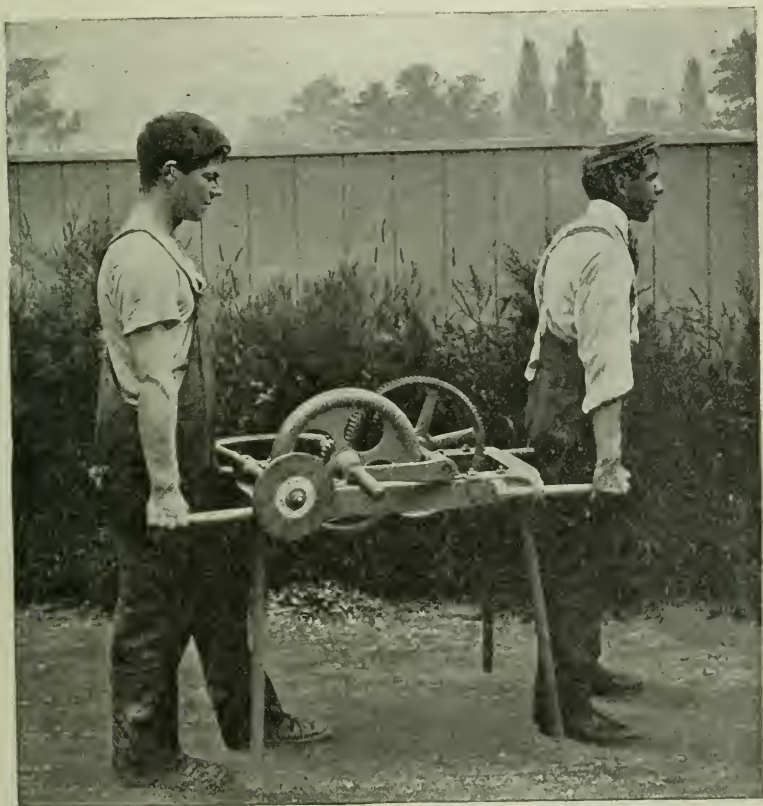


FIG. 68.—Portable grinder.

a lock washer. The bond plates are located each side of the fish or joint plate and are connected by two 4/0 wires.

The No. 2 C. & S. bond is similar to the No. 1, only that it is larger and is bolted to the rail with two 1-inch bolts.

The No. 3 C. & S. bond is similar in general design to

the No. 1 and No. 2, but differs in that only one No. 4/0 wire is employed, and is twisted in a circular loop at ends to fit in a circular groove in bond plates, the copper and iron plates are drawn to the web of the rail by one 1-inch bolt with lock washers.

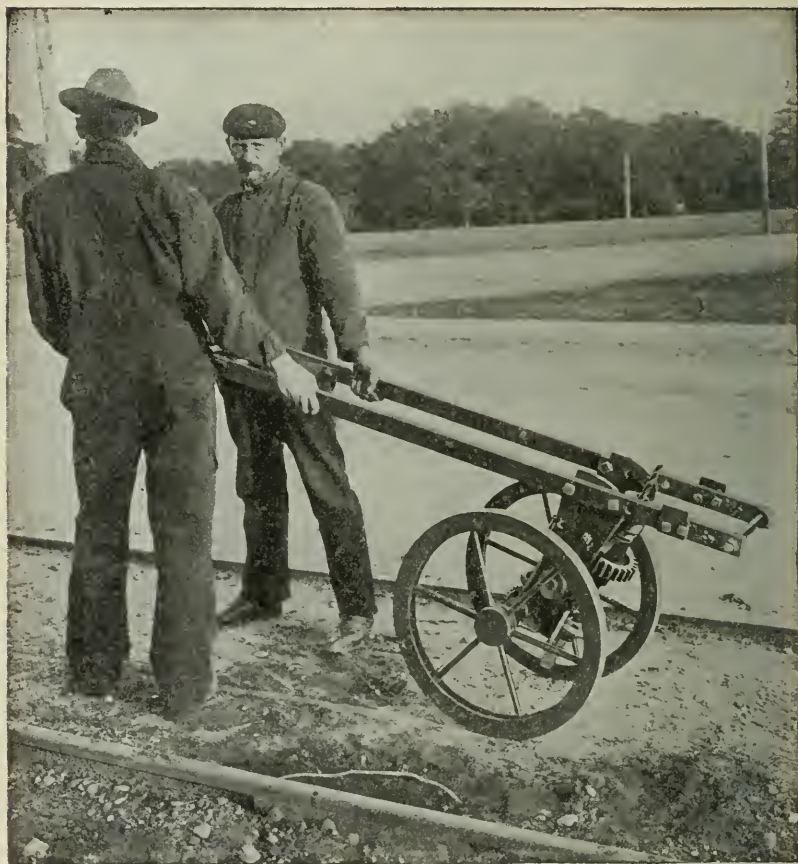


FIG. 69.—Portable grinder.

The No. 3 bond has been principally employed on tee rail, although it is as well adapted for girder rail.

The following cut (*Fig. 74*) illustrates ten types of bonds tested at random, and shown in detail after having been tested. The method of testing (*Fig. 75*) was exceedingly

simple and is described below under C. & S. testing. The column marked "Ratio of Conductivity Bond to Rail" (*Fig. 75*) simply indicates the percentage of resistance that the 3 feet of rail, including joint, bear to 3 feet of solid rail sec-

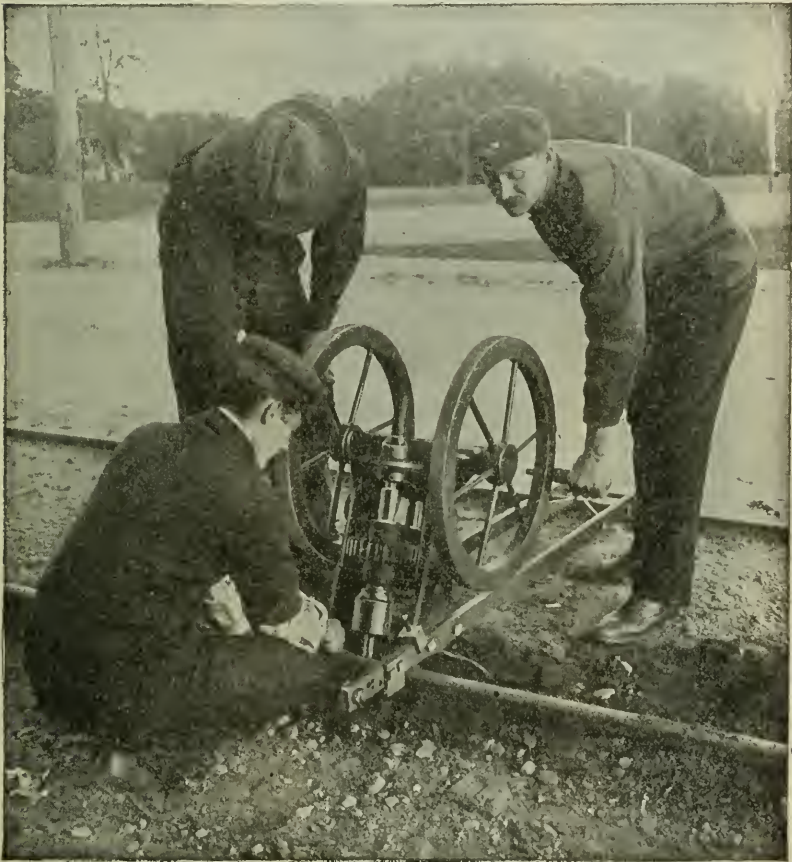


FIG. 70.—Portable drill in operation.

tion. It will be noted that the tests make a very gratifying showing.

No.	Per cent.	Years.
1	43	4
2	55	3
3	40	2
4	55	3

No	Per cent.	Years.
8	. 43	5
9	. 66	7
II	. 90	3

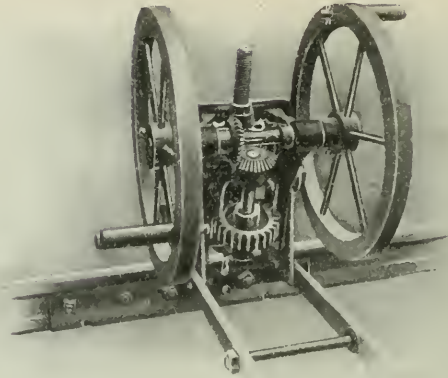


FIG. 71.—Portable drill.

The other tests show over 100 per cent., ranging from 125 per cent. in test No. 10 to 312 per cent. in tests No. 6 and No. 7.

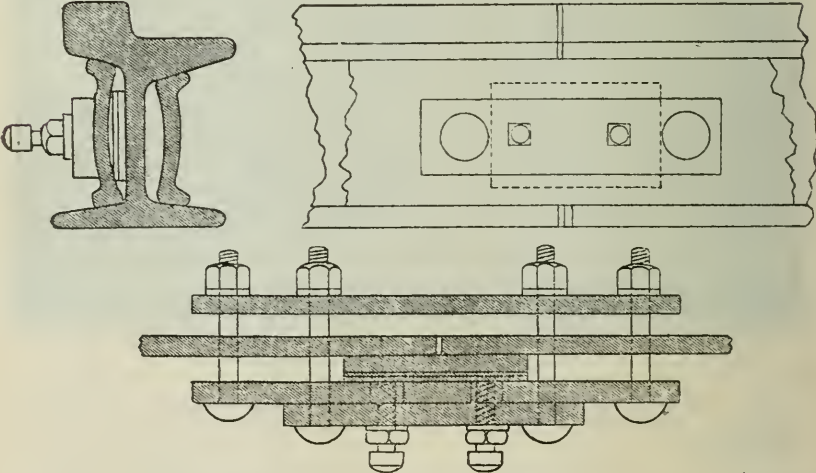
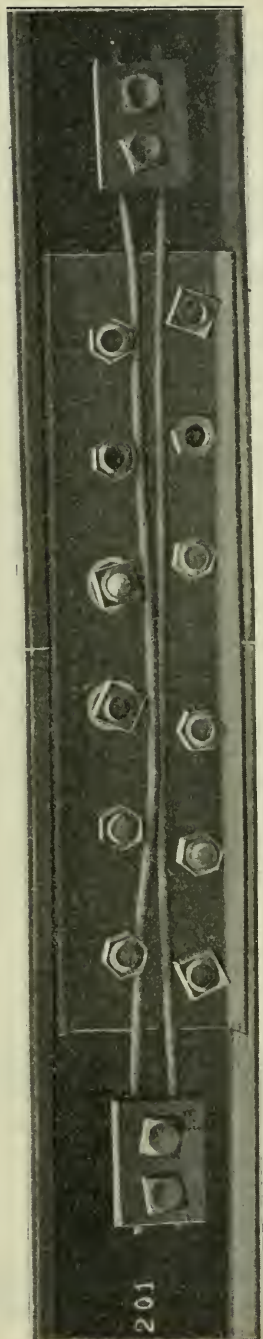


FIG. 72.—The Ajax rail-bond.

It is well to state here that it is a well-known fact, and the observation of all engineers, that successful results can-



No. 1 C. & S. bond.



No. 2 C. & S. bond.



No. 3 C. & S. bond.

FIG. 73.

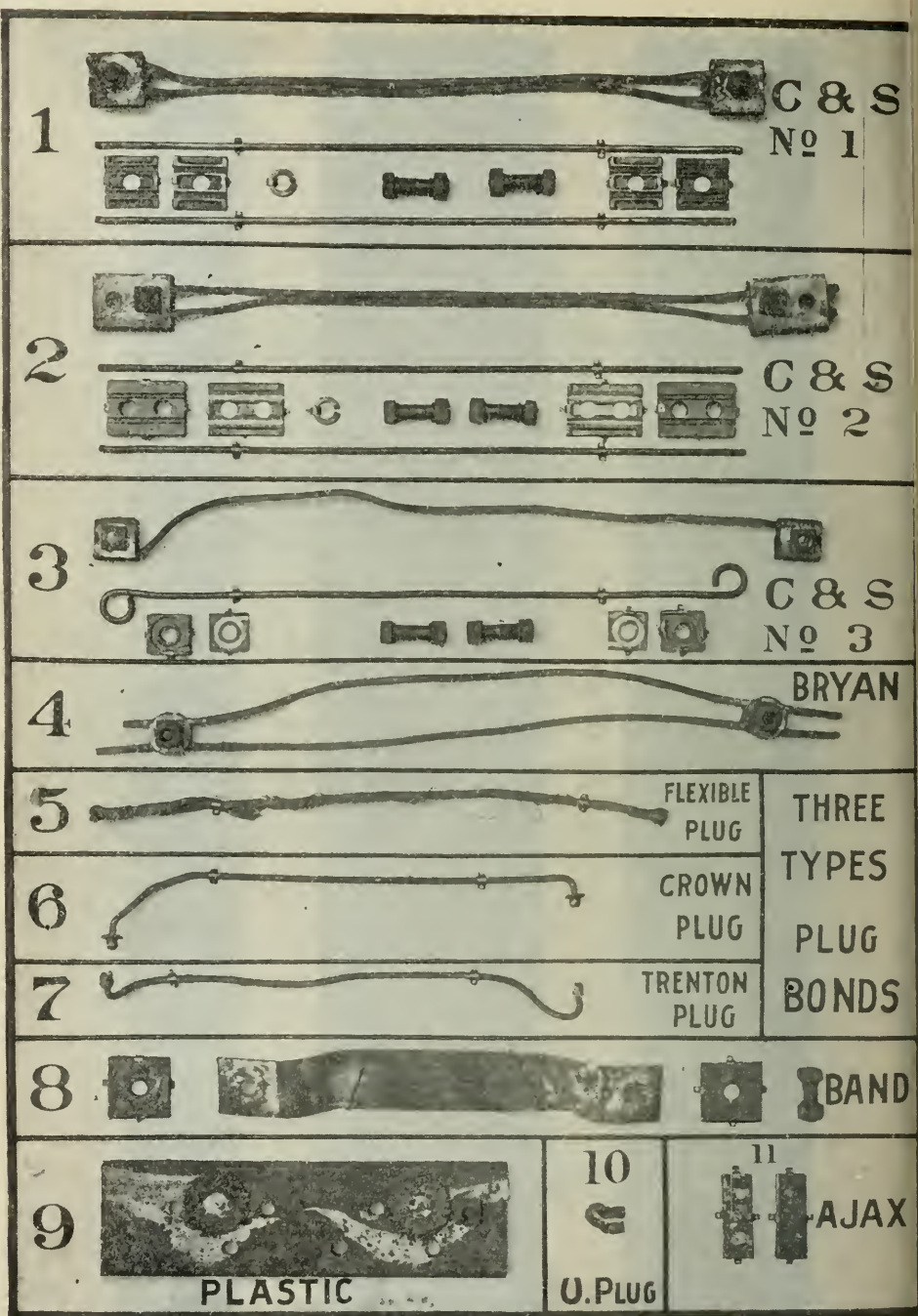


FIG. 74.—Ten distinctive types of bonds.

BOND TEST

STATION	LOCATION OF READING	TRADE NAME OF BOND	TRADE NAME OF RAIL SECTION	LINE VALUE	AMOUNTS USED	AMOUNTS OF RAIL	READING OF RAIL	RATIO OF RAIL	DATE RECD	STRENGTH
1	Am. Union 3rd St	General & Suburban No. 1	9" Girder AS Co. Sec. 200	550	200	28	12	.43	1899	Reinforced Iron Rails
2	5th St. Above Bridge Av.	General & Suburban No. 2	9" Girder AS Co. Sec. 200	545	220	27	15	.55	1900	
3	Main & Second St.	General & Suburban No. 3	9" Girder AS Co. Sec. 200	540	150	30	12	.40	1901	
4	Arch & 4th St	Brian	9" Girder AS Co. Sec. 200	550	200	25	14	.55	1900	
5	8th & Washington Av.	Kenzie Plg	9" Girder AS Co. Sec. 200	425	140	40	80	2.00	1900	
6	Madison & 4th St	Crane Plg	9" Girder AS Co. Sec. 200	430	150	24	75	3.12	1896	
7	Madison & 4th St	Thompson Plg	9" Girder AS Co. Sec. 200	430	155	25	78	3.12	1898	
8	West of Bridge	Crane Plg	9" Girder AS Co. Sec. 200	555	200	28	12	.43	1898	Cast Iron
9	1st St. Above Bridge Av.	General & Suburban No. 1	9" Girder AS Co. Sec. 200	550	200	27	18	.66	1896	Cast Iron
10	1st St. Above Bridge Av.	General & Suburban No. 1	9" Girder AS Co. Sec. 200	460	180	28	35	1.25	1899	
11	1st St. Above Bridge Av.	General & Suburban No. 1	9" Girder AS Co. Sec. 200	660	160	20	26	.90	1900	

C. & S. R. W. Y. CO.
SEPT. 13, 03.

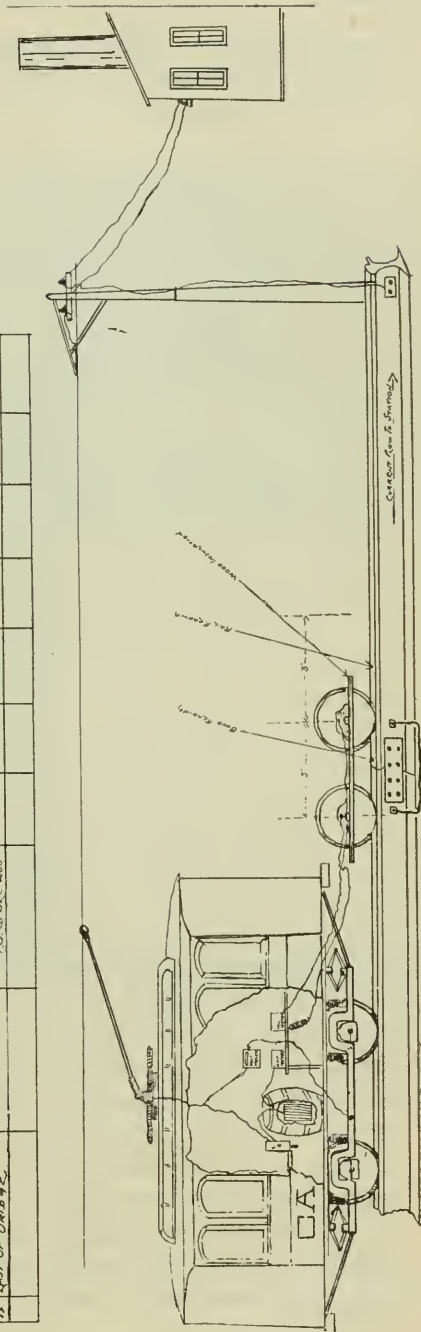


FIG. 75.

not be obtained from bonds on track where the rail joints are not maintained reasonably tight. A loose rail joint will impair any bond.

CONANT'S METHOD OF BOND TESTING.

Design of contact apparatus. The chief problem to be solved is that of making, under all conditions, good contact with the rail at the three test points. This has been accomplished as follows :

The contact apparatus consists of a center pole with steel chisel welded to socket at its lower end, to which are bolted by one thumb-screw, two extension beams reaching out on the rail, 3 feet on either side. These carry two hardened steel chisels which are sharpened so as to bear at their centers. The edges are set so as to extend in the direction of the length of the rail, while the center chisel edge is at right angles to the rail length.

The extension beams are of very tough and elastic wood, of varying cross-section, so as to secure the best combination of rigidity and elasticity. The wrought steel knees, by means of which the extension beams are bolted to the center chisel, are permanently fastened to the beams in such positions that when the T is placed on the rail, the outer chisels touch first, while the center chisel edge is about an inch above the top of the rail. Then, by resting the hollow of the foot on one side, near the center, the T is sprung down so that center chisel rests firmly on rail. This springing action forces the other chisels outward with a scraping movement that cuts them into perfect contact with the rail. An additional means is provided for intensifying this cutting effect, by pushing the handle of center pole back and forth between the positions indicated in the photograph by the dotted pole handles. This causes both outer chisel edges to cut through the scale on the rail produced by the rolling action of the car wheels, but does not disturb the contact of the center chisel.

As the best quality and temper of steel is used in the construction of the chisels they will retain their edge during a large number of tests.

The device for sharpening them is simple and rapid, and consists of a small flat stone that is furnished with and carried in case of instruments. This cuts very quickly, and to



FIG. 76.—R. W. Conant's T-pole bond tester.

stone up the chisel is but the work of a few minutes, as they do not have to be removed or in any way disturbed from their places.

The contact apparatus is portable and self-contained. By

loosening one thumb-nut the outer beams are brought up to the center pole, making it very easy to carry.

Method of testing. With the T-pole connected to instrument and telephone in position, the operator places T-pole on rail with rail joint about a foot from the center chisel. The instrument is started by its release switch at the side and the balancing switch is placed on point numbered 1.

A roaring sound in telephone indicates that balancing switch is to be moved to point of silence. When this has been done the number at which switch stands is read off. This number shows the value of resistance of the rail joint in terms of the standard length of rail spanned, which is 3 feet.

For example, if the point of no sound is found, then the resistance of rail joint is equal to twice the 3-foot length mentioned above, or 6 feet of rail. This indicates a fair condition of bonding, bad joints running considerably above this amount. As it takes but a moment to shift the switch completely around its circle, the test of a joint is made very quickly.

C. & S. TESTING.

C. & S. method of testing. The method employed by the Camden & Suburban Railway Company for all its ordinary testing, is with a car having mounted therein a barrel of water, rheostat included in circuit, a Weston ammeter, also a Weston voltmeter, to obtain line voltage. A small truck with wood framing having two axles and 33-inch wheels on 3-foot centers, with a Weston milli-voltmeter located in car and having its terminals connected to the axles of small truck, the car is run so that the small truck will trail between car and power station. As all readings are taken relatively, that is, comparing readings of equivalent joint lengths and solid rail lengths, nothing need be done except to run and make notes. If, however, any unusual reading arises the joints may be tested separately by raising and insulating the wheels of the small truck on the rail; measurements are not desired to be made.

In many cases ordinarily all that may be used is a Wes-

ton voltmeter taken around by a man and a boy with leads to compare drop around joint with solid rail.

In addition to the above, at reasonable intervals the bonding of a railway should be inspected, tested and reported upon with suggestions from some good recognized engineering expert.

Frequent tests over a system is positively necessary, as defects will develop, notwithstanding what form, kind or make of bond is employed. Loads will change, service increases or grows, track becomes worn, special work gives out, underground piping is changed, modified or increased. Perhaps one of the weakest features in bonding is over railroad crossings, and around special track work—too much care cannot be exercised at such places. As a rule, look for high resistance at such places, and particularly where low joints are observed.

Railroad crossings and special work are peculiarly easy to guard. It has been the practice of the writer for some years to cross bond from one side of a railroad crossing to the other, using 4/0 insulated W. P. wires in sufficient number, proportioned to the load, and carried under the railroad tracks in a terra-cotta pipe.

As to the question of concealed or exposed bonds, this question must be settled purely by the environment and conditions under which the track is to be bonded.

An exposed bond, while subject to theft on open-track work, has many advantages when it can be employed, in that it is always subject to quick inspection.

As the real figure of merit of a bond is its life and low resistance, the exposed bond has the advantage of longer life and to all intents and purposes no material difference in resistance in comparison with the concealed.

In paved streets, the question of exposed or concealed bonding in the writer's opinion is not to be considered, as it resolves itself into solely a question of life, conductivity and cost, design being of last importance, design only entering into the question as a matter of final detail when considering the character of joint- or fish-plate.

In conclusion, the writer wishes to emphasize the follow-

ing facts as the results of his observation and experience.

(1) In considering any bond, observe always :

Resistance	{ Obtain actual resistance data. Figure costs to obtain same. Conductivity compared with other bonds. Usually compare 3 feet of rail, including joint, with 3 feet of solid rail section.
Life	{ Study life of bonds, behavior under practical operation. Make frequent inspection of bonds in service.
Tests	{ Have frequent tests made on bonding. Look for trouble at all special work and low joints.

The writer wishes to acknowledge the courtesy and kindly spirit shown by the following manufacturers and engineers in furnishing data for this paper :

Mayer & Englund, Ohio Brass Company, American Steel Wire Company, Chase-Shawmut Company, Harold P. Brown, R. W. Conant, General Electric Company, Ajax Metal Company, Albert B. Herrick, H. A. Johnson.

In addition to this paper, the writer wishes to add thereto as an appendix a communication from Mr. A. B. Herrick, consulting engineer, describing his testing apparatus; an article by Mr. Harold P. Brown, describing evolution of bonding; and to refer to the very complete rail bond catalogue, dated June 1, 1902, issued by Protected Rail Bond Company of Philadelphia, which is replete with engineering facts and data, and supplemented by an article contained therein from the pen of Mr. A. B. Herrick, consulting engineer, of New York.

APPENDIX.

ROCHESTER, N. Y., September 14, 1903.

W. E. Harrington, Manager Camden & Suburban Railway Company, Camden, N. J.

DEAR SIR :—In answer to your favor of September 8th, I enclose herewith the photograph of my autographic recording apparatus. The method of operating is as follows : the fall of potential on each rail is taken by two sliding brushes 4 feet apart on each rail. In order that there may always be current present on these rails, a transformer is used which gives me about 200 amperes on each rail. The drop from these rail contacts are taken to two Weston milli-voltmeters, which have a commutator over the scale which they pass, and these hands bridge a spark gap, which spark is conducted to the surface of the record paper, which record paper moves at the rate of 1 inch

per 100 feet traveled by a test car, and the spark traces the record of the movement of the hands at every instant as the car progresses along the track. The height of the deflection of the mark line on the record, when the brushes pass over a joint in the rails, gives the resistance of the joint in terms of 4 feet of rail.

There is also, in order to protect these instruments, an automatic relay which cuts out the instrument when it reads beyond an adjustable point, which is changed depending upon the current density required for the rail to carry at the different portions of the system. When this relay operates, it also moves a pen and indicates a poor bond at that point on the record, there being provided a pen for each rail. The way these bonds are located on the record is by means of a third pen, which draws a continuous line which is open from one curb to the next in case of street intersections, crossings or special work, and, immediately after this location is given, a number is telegraphed by the side movement of the pen, which corresponds to the number assigned to this intersection or special point of location. In this way any bond can be located by measuring on the scale of 1 inch to 100 feet on the record. In interurban work when the automatic moves, it also actuates electrically-controlled valve, which squirts whitewash or paint on the track at the poor bonds.

Briefly, my experience in bonding rails is that in the cast weld made since 1898 the bond at the beginning of the pour is of lower resistance than a 90-pound rail of the same length as the weld. At the end of the pour it runs up to 3 feet of the 90-pound rail. The electric weld is much more uniform as now made by the Lorain Company, and is less than the equivalent length of rail over which the connection is made. In flexible bonds with solid head terminals, those put in by means of compressor giving an effect of compression of 30 tons have lower initial resistance than any other mechanical method of connecting the bond to the rail, and when the flexible portion is cast into head portion, it shows greater permanence under poor track conditions than any other method used in constructing these bonds. The bond soldered to the rail, where the laminations are presented edgewise to the ball of the rail, shows the best form of this construction, but I have not had a life-test on these bonds.

Hoping this data will be useful to you, I remain,

Yours truly,

(Signed)

ALBERT B. HERRICK.

RAIL BONDS AND ELECTRICAL CONTACTS FOR HEAVY CURRENTS.

BY HAROLD P. BROWN.

The writer has given very careful study to this subject and, as is shown by papers read before this Institute in '96 and '97, has always advised heavy bonding and low contact resistance.

These views were at first received with a smile, since it was only a few years ago that the leading street railway electricians felt perfectly satisfied with their track circuit after burying a No. 2/0 copper wire under the right of way and connecting it to each rail with a No. 0 tap and a channel pin. Many of these gentlemen would tell you seriously that the earth was a "reservoir

of electricity," or a "conductor of infinitely low resistance," and that therefore a No. 2/0 wire was more than sufficient to do the necessary work.

They were surprised to find after a very short service that their "supplementary wire" had practically disappeared, and the remedy for this disappearance was supposed to be found in the use of tinned copper wire. Later the "supplementary wire" was definitely abandoned and scraps of No. 2/0 trolley wire were used as bonds around the angle plates by means of handy but deceptive channel pins.

Still later bonds of wire were made with enlarged terminals which were riveted into holes in the rail. This riveting was slow work and gave unsatisfactory results, and the next step in advance was what is known as the "Chicago" bond, whose enlarged terminal was expanded into a hole in the rail by driving a tapered steel pin into a cylindrical hole in the center of the bond terminal. At first these pins were driven from the side of the rail opposite the bond which was held in place during the driving by a suitable lever or clamp.

The next improvement in this type of bond was driving the pin from the same side of the rail as the bond, and reducing the sectional diameter of the hole through terminal at its outer end. The steel pin then displaced the metal on the far side of the terminal and enlarged its external diameter, keeping it from falling out.

An endless number of bond terminals have been devised to effect a contact between a copper bond and a steel rail. But nearly all of their inventors did not consider the fact that the ratio of copper expansion under heat is greater than that of steel.

Therefore, if a cylinder of copper is compressed even with hydraulic pressure into a cylindrical hole in a steel rail and the metals heated, the copper must occupy greater cubical space than before.

It cannot expand in the direction of the steel walls surrounding it, therefore all of the expansion must take effect in a line parallel with the center of the cylinder, thus increasing its length while heated. When, however, the metals are allowed to cool the contraction takes place equally in all directions instead of entirely in one line as did the expansion. Therefore when the cooling is completed the copper cylinder is of less diameter than before. Into this small space moisture is sure to penetrate, forming an incompressible layer of iron oxide.

When the next heating takes place the same process is gone through and the copper is still further reduced in diameter. Finally, though the mechanical joint between the bond and the iron may seem perfect, the layer of iron oxide may be so thick as to practically ruin the conductivity of the bond. It is well known that in boiler or girder work, iron rust will inevitably form beneath the head of a steel rivet applied under hydraulic pressure in a steel plate with exactly the same coefficient of heat expansion.

But perfection of contact between copper and steel is not the only problem in rail bonding, since even with the best type of joints there will be some motion between the rail ends under passing cars and with difference in temperature. It was found that the solid wire bonds crystallized and broke between the terminals, therefore the solid wires were replaced by flexible copper strands with enlarged terminals cast or welded on the ends.

It was then found that stranded copper bonds with cast copper heads could be fastened more firmly to the rails by screw or hydraulic compression than could similar bonds which were applied by driving the conical pin. However, the great rigidity in the terminal had the effect of causing the strands to wear out the sooner. A similar effect was produced when copper bonds were welded to steel rails, with the additional disadvantage that welded steel and copper form a thermo-electric couple, and the loss due to the Peltier effect of current transmission was often far greater than the resistance loss.

Returning for a moment to the matter of contact between two metal surfaces, any one who has ever scraped a slide valve to a fit will appreciate the fact that metal plates, even when ground to a "true" surface, are nothing more than a series of high points surrounded by depressions which are clearly shown by the microscope. Realizing this fact and knowing the high resistance of iron oxide on contact metals, in 1894 an inventor hit upon the scheme of coating steel and copper contacts with an adherent layer of amalgam applied by an alkaline process. On this prepared surface a layer of a plastic metal was placed and as this filled all the inequalities of the contacts and prevented oxidation, currents could be transmitted at the rate of 1,500 amperes per square inch of section without contact loss. From this scheme was evolved the plastic rail bond in which a bit of plastic metal is used to bridge the space between rail and angle plate.

The metal putty is held in place by a case or ring of cork material, which is normally 50 per cent. thicker than the space between the rail and the plate; it is therefore compressed when the plate is bolted down, thus effectively sealing its contents. The plastic material adhered to the amalgamated surfaces and maintained a contact of low resistance for years in spite of the motion due to passing cars of temperature changes. The writer was one of the first to use this type of bond with satisfactory results both at the outset and after many years of use.

Bonds of this kind installed by the writer in 1895 showed in 1900 an average drop of .001 volts, while a reading of the same length of unbroken rail section gave .003 volts.

The following letter, dated August 21, 1903, has recently been brought to my notice, which shows even better results after seven years' service:

"In August, 1896, we received two plastic bonds as sample. I had our foreman, Mr. Hullin, place them on a 51-pound joint of Johnston girder rail. The bond had never been disturbed until a few days ago. I was at the time making some tests with a Conant bond tester. When I came to this joint I found the resistance was so much less than in the others that I determined to have it opened, so I could account for its low resistance. After opening it, I discovered that it was the joint with the plastic bond, which showed no more resistance than the rail itself. After having been under service nearly seven years, I found the alloy and contact of bond in perfect order.

(Signed) F. A. Ross, *Supt. Railway Dept.,*
Sacramento Electric, Gas and Railway Co."

To the average engineer this type of plastic bond does not appeal, since it does not seem mechanical, and it is evident that if the angle plate gets loose the material of the bond will be lost.

It is also evident that any other type of bond with loose angle plate will soon be destroyed.

The use of this bond and familiarity with the permanence of the plastic alloy contacts led the writer to design a bond composed of an amalgamated copper strip held in contact against the web of rail by screws threaded through the angle plate. One end of the strip was in contact with one rail, and the other end with the second rail. The thrust of the screws was received on a thin steel plate and both the copper plate and the web of the rail were amalgamated and covered with the plastic alloy. This type of bond has given entire satisfaction after many years of service.

A modification of this bond called the solid copper bond has had very extensive use in all parts of the world. In this bond the screws used by the writer were replaced by a pair of strong steel springs of the nut-lock type placed between the inner surface of angle plate and the amalgamated copper strip. The thrust of these springs is taken by a soft steel plate to prevent wearing holes in the copper of bond.

To keep grit and dirt away from the contact surfaces and to hold the springs in place before the bond is applied, the conductor strip is attached to a plate of cork material overlapping the ends and sides of the conductor. When the angle plate is bolted up, this cork plate is compressed so that it touches the web of the rail and the sides of the bond.

A plate of similar cork material is placed between the rail ends, thus sealing the crack which would otherwise admit dirt and let out the plastic covering of the bond. With this type of bond the motion of the rail ends under passing cars serves to improve the contact.

It is interesting to note that stranded bonds of the crown or horse-shoe type have much better conductivity and last far longer if their terminals and the holes in the rails are amalgamated and covered with a thin layer of the plastic alloy.

During the past few years the short-stranded copper bonds have broken to such an extent that few roads use less than seven inches between centers. With bonds of this length and the modern heavy rails and angle plates, mechanical breakage of the bonds has been greatly reduced. But careful tests show plainly their falling off in conductivity through corroding terminals.

Several different types of bond-testing apparatus have been designed in the past few years. One type is attached to a car which is drawn over the road, and its designer and proprietor is said to record the exact electrical condition of the bonds in a single round-trip at the rate of 6 or 8 miles per hour. This might be possible with accuracy if the rails were clean and bright. But with the ordinary conditions of track covered with dust and scale, this is impossible. Careful measurements with the milli-voltmeter will show very different results.

An ingenious type of telephonic tester has been designed by a Boston engineer, and seems to get the most rapid results with a fair degree of accuracy. But for absolute precision nothing can equal milli-voltmeter measurements of a given length of unbroken rail compared simultaneously with the same length including the bond. Even with this method, it is necessary to amalgamate the three contact spots for the instrument in order to obtain absolute accuracy.

A steel point forming a terminal of the milli-voltmeter will give results very often proportional with the amount of pressure applied or the number of scratches made in the same place on the rail.

The most serious side of this subject to an electric railway is the fact that every year the bonds are losing conductivity either from mechanical or chemical causes: breakage or corrosion.

It is now well known that poor bonds often double the amount of power required to operate a given number of cars.

That being the case, the accurate testing of rail bonds and the replacement of defective bonds is a subject whose importance cannot be over-estimated.

When defective bonds are found in a paved street or even on exposed track, it is a serious problem to apply a new bond without great expense. To use a flexible copper bond under the angle plate requires the removal of a large amount of pavement and of the angle plates. This means the loss of fully 50 per cent. of the nuts and bolts, and after the bonding is completed it is almost impossible to replace the plates in the location previously occupied. However tight the nuts may be screwed up, the fins left by the former position of the plates will prevent a tight fit. After the pavement is replaced and a few months have gone by, these fins wear away and the plates get loose, and both joint and bond are soon in bad condition.

The flexible copper bond around the angle plate requires a greater amount of pavement removed, the bond is expensive, and when the pavement is replaced, it is easily broken off by the movement of the rail.

An ideal bond for this purpose is one which disturbs the least amount of pavement in placing, which can be applied without removing bolts and angle plates, and which will permit a reasonable amount of motion between the rail and plate. This idea is very well fulfilled in what is known as the Plastic Plug bond.

Two holes are drilled through one angle plate at each joint, so that the drill passes through the base or foot of angle plate and partly through the base of the rail. After this hole is drilled and amalgamated, a small amount of plastic alloy is placed in it and a T-shaped copper plug driven far enough to dip into the plastic alloy.

The top of this T makes an amalgamated contact with the angle plate; its bottom drops into the plastic alloy in the rail. The bond permits a motion between plate and rail of $\frac{1}{4}$ inch or more in every direction without breaking the electrical contact, and the bonds have great conductivity even after many years' use.

I should not advise the use of a smaller size than $\frac{3}{4}$ inch diameter for this type of bond, as the $\frac{5}{8}$ inch size does not permit sufficient motion or expansion and contraction. The $\frac{7}{8}$ inch size, wherever the rail will permit it, is still better.

A simpler form of this type of bond is made by drilling a hole parallel with the upper edge of the angle plate, so that half of the hole is in the lower edge of rail top, and the other half in the upper edge of angle plate. After this hole is drilled and amalgamated, a copper rod of cylindrical section is driven into it and held in place by burring the rail over top of the rod. As the rail moves on the plate this rod is partly sheared, but not enough is left of the copper unsheared to make the bond of very high conductivity.

Queerly enough, even if the motion be sufficient to entirely shear the bond, a hammer blow will force both parts into intimate contact and restore the full conductivity. One form of this bond splits in advance the copper cylinder so that the halves slide on each other as the motion takes place; but this does not seem to give as satisfactory results as the solid cylinder.

Of course one important point in favor of this type of bond is its cheapness. But whatever type of bond is used, frequent inspection and immediate replacement of defective bonds is of the utmost importance.

A SILVER-LIKE METAL.

A writer in the *Aluminum World* gives the constituents of a hard alloy which has been found very useful for the operating levers of certain machines. The spacing lever of a typewriter is constantly handled when in use, and if made of iron or steel and nickel-plated, even heavily, the plating soon wears off, leaving the metal underneath exposed to rust and corrosion, a condition which, of course, is not permissible. If the levers are made of brass the matter is not helped to any extent, as the plating wears off the same as iron or steel and leaves the brass exposed, which is, if anything, more objectionable than iron or steel. The metal now generally used for this purpose by the various typewriter companies is "aluminum silver," or "silver metal." The proportions are given as follows:

Copper	57 00
Nickel	20.00
Zinc	20.00
Aluminum	3.00
	100.00

This alloy when used on typewriting machines is nickel-plated for the sake of the first appearance, but so far as corrosion is concerned, nickeling is unnecessary. In regard to its other qualities, they are of a character that recommends the alloy for many purposes. It is stiff and strong and cannot be bent to any extent without breaking, especially if the percentage of aluminum is increased to 3.5 per cent.; it casts free from pinholes and blow-holes; the liquid metal completely fills the mold, giving sharp, clean castings, true to pattern; its cost is not greater than brass; its color is silver white; and its hardness makes it susceptible of a high polish.

NATURAL BORAX.

The mineral borocalcite furnishes the base of the greater part of the borax consumed in Europe. Fifteen parts of finely crushed ore with 60 parts water, 8 parts sodium bicarbonate and 2 of caustic soda are boiled in a steam-heated boiler about three hours. It is then filtered and crystallized, yielding crystals of borax. It is estimated that 100 pounds of borocalcite will yield from 100 to 105 pounds of crystallized borax.—*Engineering and Mining Journal*.

Mining and Metallurgical Section.

Stated Meeting, held Thursday, January 30, 1904.

The Petrified Forests and Painted Desert of Arizona.

BY PROF. OSCAR C. S. CARTER.

The physiographic division of Arizona is extremely simple and well marked. There is a high plateau in the northern half of the State and a low desert area in the south; a high wall or escarpment separates them. This escarpment enters Arizona from Utah on the north and trends from the northwest to the southeast; it is really the southern border or end of the great Colorado Plateau, which includes parts of Utah, Arizona and New Mexico, and extends from Utah southward, often as a series of gigantic steps. It is called the Colorado Plateau on account of the river of that name, which has cut in the plateau the most stupendous gorge in the world—"The Grand Cañon of the Colorado." Portions of this plateau are more than a mile higher than the desert area in the southern part of the State, and, as Merriam has pointed out, it acts as a barrier to the passage of animals and plants, but it must not be supposed that the boundary is always a cliff.

In this northern plateau in Arizona there is a vast depression or basin called the Painted Desert, which is the drainage area of the Colorado Chiquito or Little Colorado, which empties into the Colorado. The corrosion of the stream and its tributaries, which are often dry, and all the other forces of erosion have cut this basin and its channel and widened it. From near the mouth of the Little Colorado this Painted Desert extends southeasterly for a distance of 200 miles, and even enters the border of New Mexico. In its widest part, near the middle, the desert is about 75 miles wide. The slope, of course, is toward the Colorado River. It is called the Painted Desert on account of the bright colors of the sandstones, shales and clays.

Mesas of bright red sandstone are common. The shales are eroded into bizarre and fantastic shapes; all of these forms of erosion are colored, blue, yellow, red or green as the case may be, and with the bright sunlight and clear, dry air, the coloring is often brilliant. The Petrified For-

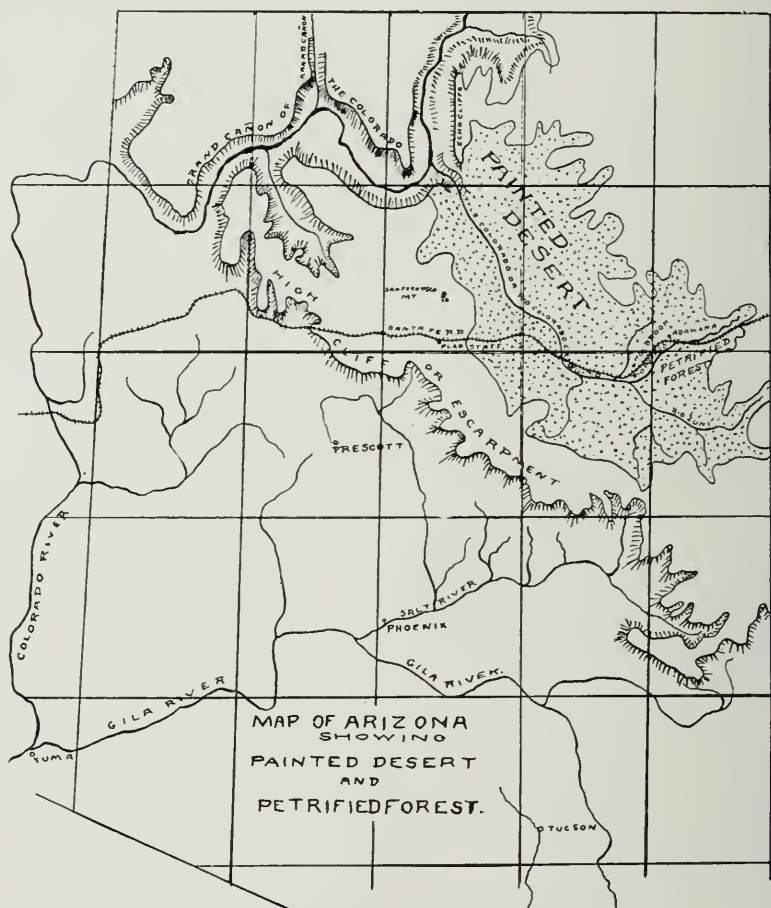


FIG. 1.

est is near the southern border of the Painted Desert, between the Rio Puerco and Zuni River, which are tributaries of the Little Colorado. The Painted Desert is not much of a basin or depression in this southern part of its area, as the

average elevation is over 5,000 feet above tide; neither has it any connection whatever with the low desert area in the southern part of the State. It is wholly in the plateau country. The Petrified Forests of Arizona may be classed among the strange corners of our country, and lie more or less off the beaten track. The general public do not as yet visit this locality as they do the Yellowstone or the Yosemite, yet it is quite accessible. More than 3,000 people visit the Yellowstone annually, and the number is increasing, yet Adam Hanna informed me, in 1889, that he had about a dozen visitors annually to his ranch on the Painted Desert, which is the nearest place to the Petrified Forest.

Thousands of visitors at the World's Fair became interested in the Petrified Forest when they admired the logs and polished slabs of petrified wood of various colors, bright red predominating. Sometimes they are cut into table-tops and pedestals. Very few, however, had any idea as to how the forest may be reached. The Mormon town of Holbrook is always associated with the Petrified Forest, probably because it is the only town of any size near the forest, except the still smaller station of Carrizo, which can be reached by a drive of 20 miles or more. If we take a folder of the Santa Fe Railroad we will see a flag station named Adamana, which is the best place to reach the forest. It is simply a signboard or mile post marked 233 Adamana, and is near the southern border of the Painted Desert, although the desert does not have the rich colors which the shales give it farther north. The forest is found scattered over from 8 to 10 square miles of territory, principally in township 17. Adamana is about 21 miles east of Holbrook. The conductor will have no compunction about dumping you down in the desert among the sage and soapweed, providing you keep on the alert and remind him not to run past the mile post. When the train rushes by you can see Adam Hanna's ranch in the distance, from which the station takes its name. The river fringed with cottonwoods (*Populus monilifera*), known as the Rio Puerco, or dirty river, runs lazily past the ranch. It is well named dirty, for it is always the consistency and color of strong chocolate. It is so muddy that no living creature is found in its waters.



FIG. 2.—View of a part of the Petrified Forest.



FIG. 3.—Agate bridge, 111 feet long, spanning ravine between mesas.



FIG. 4.—Agate log called the cannon, on top of the mesa.



FIG. 5.—Differential weathering of sandstone and shale in Petrified Forest.

On consulting a map we get the impression that it is a fair-sized river, but it is a river merely by courtesy. There are no large rivers in the arid district of the Southwest. What they call rivers, we call creeks in the East. The rainfall is slight, only 10 inches a year, often less, and evaporation so rapid that the air takes up the water like a sponge; hence, large rivers are out of the question, and some of them even disappear entirely under the summer's torrid sun. In a country like this they don't need to hang up clothes to dry, they will dry quickly enough on your back should you take a bath impromptu. Even the perspiration which comes so freely in traveling over the desert is soon dissipated by the hot dry air. It is no unusual sight, in the desert region farther north, to see a copious shower of rain falling from the clouds above, which never reaches the parched and dry shales of the desert because the hot dry air above the desert evaporates and absorbs it so quickly that it soon disappears. Even when a cloudburst occurs and the rain comes down in sheets, which is a common occurrence in the rainy season in July and August, and the arroyos are full of turbid streams of often liquid mud several feet in depth, yet in a few hours the desert is as dry as punk, and there is no evidence of a shower except the alkaline water which stands for a short time in the mud-bottomed pools. The Rio Puerco, in the summer, is not wider than a country creek and can be forded by the horses, but after cloudbursts in the higher plateau country, a stream of liquid mud 10 feet deep spreads from the mesa to the Santa Fe road, and even comes to the door of Adam Hanna's ranch. Fording the stream, however, is not child's play unless you know the ground, because the horses become mired and sink to their middle.

As Adamana is the nearest and best place to reach the forest, and Adam's ranch is the only one for miles at which the tourist can stop, our host deserves perhaps more than a passing notice. His life since boyhood has been spent in the Southwest, and has been a checkered one. He has been sheriff, herder, scout and section boss. Adam drove the stage between Denver and Salt Lake City in the early days

when it was a perilous undertaking; an Indian arrow wound in the leg testifies to his worst experience. He was also sheriff of San Juan County, Colo., and was located at Silverton, where the desperadoes made their headquarters when driven from Leadville. He was scout for General Buford for a while, and recently served two terms as sheriff of Apache County, Ariz., where he now lives. The office of sheriff in parts of Colorado and Arizona was not always a sinecure, and his reminiscences are sometimes entertaining. Adam took government claim of 160 acres and built his ranch alone in 1884. He had between 250 and 300 horses scattered over the near country, as well as many cattle. He drives cattle from Mexico to Deeming, Colo., where they are sold. When on these long journeys his wife stays alone on the ranch and plays the part of hostess.

There are no neighbors for miles. Two road-agents, who held up the Santa Fe train successfully, took supper there, but she did not know who they were until afterward. There is certainly a charm about the desert with all its disadvantages. The sunsets are beyond description. No matter how hot it is during the day, the nights are always cool. In that rare and dry atmosphere radiation is rapid, and the earth cools so rapidly that out of doors a blanket is comfortable at night. Cool nights on the desert are the rule much further south also, and in the report of the Mexican Boundary Commission, Capt. D. D. Gaillard reports temperatures of 110° F. and 115° F. in the shade, and even higher temperatures were recorded by standard thermometers; yet in the evening the temperature would drop to 65° F., a range of 50° during the day. Unfortunately it was not the shade temperatures with which the commission had to contend in traveling across the desert. The traveling was done in the open, and the low leafless flora of the desert are useless for shelter. Even the Giant Cactus (*Cereus giganteus*), which attains a height of from 40 to 50 feet, and the large and striking cactus called pitahaya by the Mexicans, which were passed by the commission near the Mexican boundary line, afford no shelter worthy of the name. At the Petrified Forest and to the north in the



FIG. 6.—Agate logs, from 15 to 20 feet in circumference.



FIG 7.—A stranded log *in situ* on an eroded ledge of sandstone, once embedded in that rock.



FIG. 8.—Enormous logs stranded on shale along the slope of the mesa.



FIG. 9.—A log *in situ* embedded in sandstone.

higher plateau country the nights are so clear that one can almost read a newspaper; Percival Lowell took advantage of this fact when he located his observatory at Flagstaff, Ariz., where some most important work has been done mapping out the canals of Mars, which has attracted attention at home and abroad. Work of this character could not be done in a smoky and hazy atmosphere like the East. At Adam's ranch the coyotes come close to the house for water from the pond; the Rio Puerco is too muddy. One can hear their peculiar bark at almost any hour of the night. The fauna and flora of the desert here are of a source of interest. Bright-colored lizards dart across the sand and an occasional horned toad seems clumsy when its movements are compared to the lightning darts of the lizards. The jackass rabbits which one starts from every clump of bushes are making sad havoc with Adam's little patch of Kaffir corn, the only crop he irrigates. Birds are scarce; the burrowing owl and desert sparrow are there, and Hanna says that one hears the mocking bird and oriole among the cottonwoods that fringe the Rio Puerco. Mrs. Hanna recently moved away from a wild cat among the branches directly overhead. Adam and a cowboy drove one from the cottonwoods and lassoed him in the open.

Small nocturnal forms of desert rats and mice and bats are met with. The sage (*Artemesia*), Mexican grease-wood (*Atriplex canescans*), soapweed, cacti and yuccas is the flora, with here and there a blade of grass struggling through the sand, scarcely enough for the cattle and horses when there is little rain. Those who have taken the trip to the Grand Cañon in the higher part of the plateau to the north during the rainy season of July and August have noticed how the open pine forests and vicinity are often carpeted with wild flowers, which soon gain a foothold after the rains. Some of these wild flowers are occasionally seen on the desert during the rainy season, but they do not last long.

An interesting fact about subterranean water for irrigation is that abundance of pure soft water is reached at a depth of less than 50 feet on Adam's ranch. The underground water of the Southwest is often hard, Adamana is

an exception. A windmill on the ranch supplies an enormous pond, more than 100 feet in diameter and 4 feet deep, with a plentiful supply sufficient for irrigation. The soil is fertile enough, and with irrigation fruits and vegetables of all kinds suitable to the climate could be raised. Under the present administration irrigation is receiving a fresh impetus, which will work wonders where irrigation is possible and reclaim much worthless land for the settlers. It has been

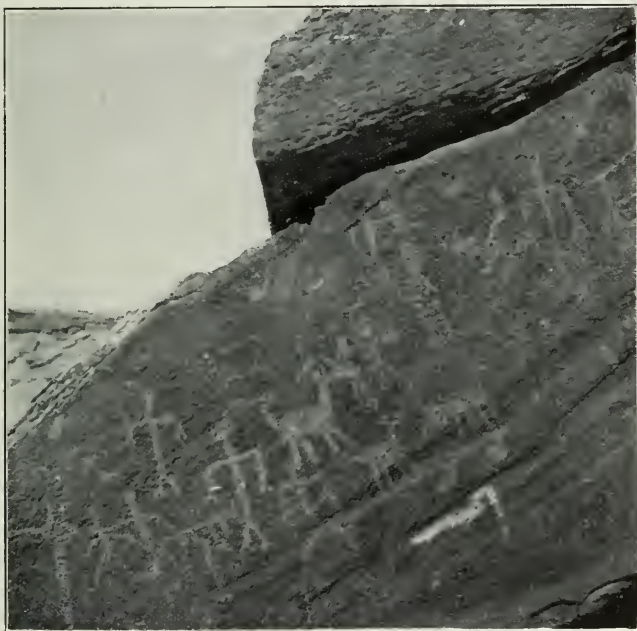


FIG. 10.—Pictographs made by cliff dwellers on sandstone, near Petrified Forest.

estimated by some that the arid land that can be reclaimed amounts to from 70,000,000 to 100,000,000 acres, an area larger than the New England States, New York and Pennsylvania combined; but it must not be forgotten that a greater part of the arid region can never be irrigated at all on account of elevation, absence of water above and underground, and other causes.

In some parts of the United States 25 acres of watershed

are required to collect enough water to irrigate an acre of ground. This helps to realize this fact. I stopped once at a little station called Humboldt, in Nevada, the surrounding desert was desolate and bare of trees; but I was surprised to find a grove of cottonwoods and a bright green sward in the struggling town, while a little fountain played at the station. It was a veritable oasis in the desert. A crowd of loungers, when questioned as to the source of the water



FIG. 11.—The Eagle's Beak. A freak of erosion of sandstone and shale.

supply, said it was piped a long distance from the mountains. They were asked, "Why not sink artesian wells?" Whereupon the spokesman said it reminded him of a question he once asked in a Kansas town. He asked a native where they obtained so much water and was informed that they piped it 7 miles from the hills. "Why don't you put down artesian wells?" he asked. "Distance just the same," replied the man.

The trip to the Petrified Forest is best made in the cool

hours of early morning. After fording the Rio Puerco, where the horses sink to their knees in mud, we soon strike the trail, and after an hour's journey we reach the mesas. These mesas rise to 60 or 70 feet above the desert. They are made up of a white disintegrating sandstone rock, which is held together by a feldspathic cement. Between the layers of sandstone are layers of red shale colored by red oxide of iron. It is at the base of and between these mesas that the petrified trees are found. The first indication of petrification one sees is bright red and yellow pieces of agate and chalcedony, showing the outlines of the bark; these are scattered over the ground long before one reaches the mesa, but no logs or large pieces are met with yet. After reaching the mesa we are strongly tempted to collect specimens, which would be considered fine enough to grace any mineral cabinet in the East, but Adam cautions us to wait, as there are more beautiful specimens farther on. Suddenly the horses make a turn around the edge of the mesa and then we see scattered over many acres enormous logs completely changed to agate, jasper or chalcedony. The sections or ends of the logs show brilliant reds, yellows and dull blues. The bark is not brilliant but dull and wonderfully well preserved, being almost lifelike in its naturalness. Some trees show even the knots to perfection; but even these trees, spread over many acres, are not the finest.

After a short drive between the mesas and another turn we come to some enormous logs. These are 4 feet in thickness and from 10 to 12 feet long. They have no branches, but the hundreds of small pieces, varying from a couple of inches to 1 foot in diameter, are probably in some cases the remains of branches. After a drive of several miles along the base and on top of the mesa through many hundreds of petrified trees, we failed to see a tree with branches or even one standing upright. All of the trees were lying on one side. Another important fact is that no tree, except one, was found which showed the entire length. There were many logs from 3 to 30 feet long. The one exception to this was well worth a visit. After clambering across the mesa we come to a ravine 50 feet in depth in the deepest part.

In the bottom are growing a clump of cedars, the only trees about the mesa. Spanning this ravine, which is 44 feet wide, is an enormous petrified tree which measured 4 feet in diameter in the thickest part. The tree does not end on the edge of the chasm, but continues across the sandstone mesa and enters a ledge of sandstone, making the length of the tree that is visible 111 feet. How far it extends into the sandstone we cannot tell. This is the only perfect tree we saw. It is interesting to account for the preservation of this entire tree and also to account for the fact that logs instead of trees are the rule.

It is the writer's opinion that some of these trees were broken into logs after they were petrified, and while they were imbedded in the solid rock. The entire plateau country comprising New Mexico, Arizona and beyond, were elevated in recent geological times (Tertiary) from 4,000 to 8,000 feet above tide. This elevation was gradual, but the strata, nevertheless, were subjected to pressure and enormous strain, which fissured them and cracked the trees while they were still imbedded in the sandstone and shale, before they were loosened by erosion. This seems more reasonable than the statement that they were split into sections by heat and cold, although, doubtless, many were. This large tree spanning the ravine has been called the natural bridge of agate. Unfortunately, there are several transverse cracks in this tree, and one near the mesa seems to extend entirely through the tree, making the position insecure. This is shown in the photograph. It should be braced in some way so as to prevent the entire collapse of the tree into the ravine below, as it will always be a source of wonder and interest to tourists, when the area is set aside as a Government Park, which will probably be done, as the bill has already passed the House. It may be that these trees are not *in situ*, but floated there in past geological ages, perhaps, down an ancient river into an inland sea, where they were buried in the sand and mud near the shore after they became waterlogged. These layers of mud and sand became shale and sandstone in after years, when the sea receded or evaporated owing to a change in climate

and other causes. The fact that shifting currents were active is readily proved. Photographs of sandstone showing cross bedding to a marked degree were obtained. It may be, however, that these trees grew along a shore line that was afterwards submerged, and they became buried in sand and mud. They are much crowded and the former view may be the correct one, although we cannot prove it.

How do we account for the fact that these trees are found stranded at the base and on the top of mesas? This is very simple. These mesas were once a continuous plateau of sandstone and shale, when a break, crevice or line of weakness once began, erosion soon completed the work and the gaps widened until finally the plateau was dissected into a series of mesas. As the disintegration of the sandstone and shale proceeded, the trees imbedded in the rock would be loosened and finally roll down to the foot of the mesa, where the most of them are now found. As these strata are of mesozoic age, many layers of rock must have disappeared since that time by erosion, so that the trees at the foot of the mesas and in the arroyos are not in place, but came from a higher horizon of sandstone which has disappeared by erosion. There are, however, many trees in place imbedded in the solid sandstone rock, their branches and trunks projecting from the edges of the mesas and plateaus; but most of these trees in place are in the highest part of the forest at an elevation of 5,700 feet above tide; these trees in place are several hundred feet above the valleys and arroyos in which the loose stranded trees are found. The Natural Bridge is the largest tree in place, and most of the trees in place are found in a coarse-grained sandstone, with a feldspathic cement; the cross bedding indicates shifting currents. While examining one of these trees, a lizard of brightest green darted under a rock. It seemed to be about 8 inches long and the scales fairly glistened in the sun. That layers of sandstone of immense thickness have disappeared from the top of the mesas one can readily see at a glance, because some of the trees are loose on top of the mesas where they were deposited when the rock eroded away. All of the trees have been changed to some form of

quartz, either agate, chalcedony, jasper or opal. By far the greatest number have been changed to the varieties of silica which have a waxy lustre. It is a well known fact that quartz resists erosion of all kinds better than any other mineral. It is practically insoluble in mineral acids and also in cold water. The only solvent met with in nature besides some organic acids, from decaying wood and vegetable matter, is hot water containing the alkalies, potash and soda in solution. So we may consider quartz one of the most insoluble minerals known. When granite rocks are exposed to the action of waves along the shore line, parts of all the minerals of the rock dissolve in the course of time except the quartz, and that forms the beach sands. Along the Atlantic Coastal Plain are quartz sands, and this would not be the case were it soluble and easily eroded. We can understand from this then, why petrified trees have resisted erosion and lasted so many ages, while the sandstone and shale in which they were imbedded have disintegrated and been swept away. Sandstone is simply made up of grains of sand held together by some cement. It may be clay, iron oxide, feldspar or lime carbonate. If the cement be slightly soluble the grains of sand are soon loosened and the rock disintegrates and is washed away.

We can easily see from this how the mesa in which the trees were imbedded has eroded, while the trees rolled down to the base of the mesa or were left stranded on top. Several peculiar mounds of rather striking appearance were noticed on the desert near the mesa, not far from the trees. These have been pronounced by some, after superficial examination, to be extinct geyser cones. There is no evidence whatever to support such a statement. The mounds are simply mounds of disintegrated colored shale, the peculiar form being due to weathering; no indication of geyserite was found. The mounds are certain to attract attention. They are due to erosion, because some mound-like forms were seen capped with a pinnacle of harder resisting sandstone. As soon as this topples over and disintegrates and is washed away by rains, then the underlying and softer shale will be moundlike in form. One of the most interest-

ing and bizarre forms due to erosion, which surpasses many unique forms in the Garden of the Gods, is the so-called Eagle's Peak.

This is a mound of peculiar shape at the base, surmounted by a shaft about 25 feet high, on top of which was a slab; both shaft and slab are of sandstone. When erosion proceeds far enough and the peak topples over, one of those peculiar mounds will be formed. The geological horizon to which the sandstone and shale of the forest belong is in dispute. J. W. Powell, formerly director of the U. S. Geological Survey, claims to regard them as Jurassic, while the other evidence seems to point to Cretaceous age. They occur probably in the Shinarump group of Powell. Sections of this wood under the microscope show that it is conifer. In 1853 Mollhausen discovered a petrified forest in a ravine near the Little Colorado in Arizona. The wood was submitted to Dr. Goppert, who pronounced it a conifer belonging to the *Abitineæ*. The Rio Puerco is a tributary of the Little Colorado. One of the logs in front of the U. S. Museum at Washington was taken from the mesa 2 miles north of Fort Wingate, N. M., which is not far from the Rio Puerco and just over the Arizona line. They were studied by F. H. Knowlton, who states that they are the same as Goppert's *Araucarites Mollhausianus*. Not *Araucarites* as that genus is understood, but *Araucarioxylon Arizonicum* from the fact that most of the wood is found in Arizona. F. Kunz, who visited a part of the forest near Carrizo, Ari., states, in the *Popular Science*, that he found trees projecting from volcanic ash and lava, which are covered with a depth of sandstone from 20 to 30 feet. He says the trees lie in gulches where the water has worn away the sandstone and the trees were overthrown and covered with a volcanic ash and tufa.

Dr. P. A. Dudley, of New York, examined this wood and says it belongs to the genus *Araucaria*, and that *Araucaria excelsa*, the present Norfolk Island pine of the South Pacific, grows to a height of 150 to 200 feet. Other pieces, he says, resemble red cedar *Juniperus Virginianus*. Be this as it may, many specimens show that the wood was going to

decay before it was petrified. The writer was not able to find any trees imbedded in lava of any kind; all the trees in place were imbedded in sandstone. The paleobotanist, Lester Ward, states that all the imbedded trees he examined were in sandstone. Scattered over the desert, way beyond the mesa, the writer found isolated pieces of lava, very small. Cinder showers and volcanic ash were common in Arizona in past ages, and lava flows are so common in the plateau country that one can pitch his tent almost every night on a lava flow, but most of the flows took place in tertiary times and many are more recent still, as their fresh surfaces little worn by erosion indicate. The trees are of mesozoic age, so that these trees were petrified long ages before the most of the lava flows took place. The writer believes that most of the petrification took place in the sandstone and shale, and was due to soluble silicates derived from decomposition of feldspar, which is the cement binding the sandstone. The silicate of potash or soda produced the petrification when it came in contact with the vegetable matter or trees that were imbedded. The silicates are soluble in rain water, and as they percolate through or over imbedded woody material the organic acids derived from the decomposition of the wood will decompose the silicate of potash and set free silica in the amorphous or gelatinous form, which will be precipitated on the wood and in the pores until the substitution is complete. In Pennsylvania pieces of petrified wood are found in new red sandstone; a feldspathic cement binds the grains of sand. We find petrified wood in many other localities far removed from lava.

Near Adam's ranch a small plant was erected by a Denver company, who intended to crush the agate trees and use the powder for an abrasive agent as a substitute for emery. The plant was never started, probably because of the introduction of a harder abrasive called carborundum, made in the electric furnace from coal and sand. At Sioux Falls, Dak., they polish petrified wood and make magnificent table tops and pedestals.

In the Yellowstone Park (U. S. Geological Survey Mono-

graph XXXII, Part 2) are found many petrified trees, but they are standing upright. They do not rise to any great height. They are mostly trunks on the slopes of mountains, and the highest of them rise to only 20 or 30 feet. They are found near Lamar River, the finest exhibit being on Amethyst Mount and Specimen Ridge, near the road between Mammoth Hot Springs and the town of Cooke, Mon. Yancey's fossil forest is one mile south of his hotel, on the slope of a hill 1,000 feet above the valley. There are only two trees of considerable size, the largest stump being 15 feet high and 13 feet in circumference. The bark is not preserved, so that the true diameter cannot be ascertained. They belong to the genus *Cupressoxydon*. Some trunks rise only a few inches above the ground. Some of the trunks near Specimen Ridge are sequoias. In early tertiary times these forests were supposed to have been buried under debris ejected from volcanoes and afterwards surrounded with water charged with silica, which petrified them. The largest trunk in the park is 10 feet in diameter. These trees which grew in tertiary times cannot, of course, be compared in age with the trees of the Petrified Forest, Arizona, which grew in mesozoic times.

CENTRAL HIGH SCHOOL,

PHILADELPHIA, January 30, 1904.

Correspondence.

SOME FURTHER NOTES ON CAST IRON.

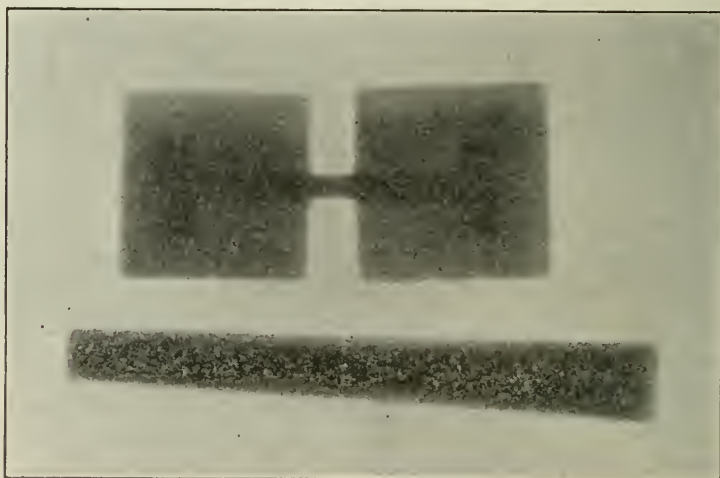
To the Committee on Publications :

(1) Noticing the comments of Dr. Goldsmith (entitled "Does Cast Iron Grow?") in your current issue, I would say that I think it highly probable that the pressure caused by expansion of occluded gases in cast iron plays a prominent part in the phenomena noted in my paper on "Recent Investigations and Discoveries in Cast Iron," printed in the *Journal of the Franklin Institute*, February, 1904. I believe, however, that these gases ultimately escaped through the pores of the metal which has been expanded by repeated heating and cooling, and the intermolecular spaces are now filled with air.

In a paper entitled "The Mobility of Molecules of Cast Iron," read before the American Institute of Mining Engineers, at its recent meeting at Atlantic City, I stated my reasons for this belief, and in the original address

given at the Franklin Institute, I performed an experiment to prove this, the account of which I omitted to incorporate in the printed paper referred to by Dr. Goldsmith.

The experiment was as follows: A small tank filled with water was placed in the lantern and its image thrown on the screen. A section, $\frac{1}{4}$ -inch thick, of a cast-iron test bar before being expanded by heating, and a section, of the same thickness, cut from the same bar, after having been expanded 30 per cent. in volume, both placed in the tank, side by side, showed a surprising difference in behavior. It was observed that bubbles of gas were forced out from the entire surface of the expanded metal by the pressure of the water, while no such action took place on the surface of the untreated metal. I stated that the piece had been immersed in water several times, and the first time it gained 870 milligrams in weight, due to the absorption of water. When



Radiograph made with radium of 10,000 activity (Curie's scale), showing remarkable permeability of cast iron, both expanded and untreated.

the piece is allowed to remain in a warm room for several hours after removal from the water, the water evaporates and air again enters to fill the void; this may be repeated many times.

The metal does not appear porous to the naked eye, but photo-micrographs show very clearly innumerable spaces or cracks, permitting the escape of occluded gases and ingress of water or air, as the case may be.

(2) Quite recently Messrs. Williams, Brown and Earle, of this city, have made some interesting shadowgraphs, or radiographs, for me by the aid of radium-bromide of high activity, imported from Paris, showing that emanations from this wonderful element discovered by Professor and Madam Curie, will penetrate cast-iron readily. In the half-tone illustration two pieces of the same cast-iron test bar, already alluded to in this communication, were cut to the same thickness, viz., $\frac{1}{8}$ -inch, one before and the other after expansion.

These were laid upon a strip of lead (a metal which is almost impermeable to the emanations from radium) cut to a sort of dumb-bell shape. A tube containing 100 milligrams of radium of 10,000 activity (by the Curie scale), was placed centrally by measurement, 4 inches, above the pieces of cast-iron.

A wedge-shaped piece of steel, of the same thickness, was placed close to the cast-iron pieces, for comparison, steel being less permeable to these emanations than cast iron. After an exposure of thirty-eight hours the negative, which was placed beneath those objects, was developed and the print made therefrom.

Several curious and interesting phenomena may be noticed, *e. g.*, the rays passed through both pieces of cast iron, and were intercepted by the lead strip, making a distinct image of the lead strip underneath the cast iron.

The central portion of the lead exposed to the rays between the two pieces of cast iron appears narrower than the portion seen through the cast iron, and looks more like a round rod than a flat strip. Also, penumbra show around the edges of the cast iron and steel, indicating that the rays are in some degree deflected around the edges.

The fact that such dense metals as iron and steel are permeable to emanations from radium is very interesting, and may prove of practical value in detecting flaws. I am informed that the "X rays" will not penetrate these metals.

(3) Since my paper on recent investigations and discoveries in cast iron was read before the Mining and Metallurgical Section of this Institute, a disastrous fire has occurred at Baltimore, which has incidentally furnished convincing evidence of the great importance and practical value of a thorough understanding of the laws governing the behavior of cast iron and steel when subjected to high temperatures.

The following extract from a letter which I received from an officer of the Land Title and Trust Company, of this city, dated February 9, 1904, will prove this: "The chief engineer of the Land Title Building, who went to Baltimore to inspect the effect of the conflagration upon the Continental Trust Company's 16-story building, tells me that while the entire inflammable contents of that building were "roasted" and consumed, the steel framework is apparently plumb and intact. He also says that the cast-iron framework of the doors (which was set in granite) has expanded to a considerable extent, and has not again contracted. He says this permanent expansion is very noticeable."

I have reason to believe that if the framework of the doors and windows of this "modern fire-proof sky-scraper building" had been of light-steel construction, instead of cast-iron, and the doors sheathed with thin sheets of steel, or made of non-combustible material, the valuable contents of the building might have been saved from complete destruction by fire.

At all events, it may be assumed that if the facts given in my paper had been generally known and understood by architects and constructing engineers, the framework of the doors and windows of the modern steel skeleton buildings would not have been made of so unsuitable a material as cast iron, and I anticipate that in future constructions of this character these errors will be avoided in view of our present knowledge and recent experience.

Engineering News, of February 18th, prints an extended paper on the

effects of the Baltimore fire on so-called fire-proof structures. It says: "One of the most surprising effects of the fire was the noticeable extent to which cast iron had suffered permanent bends. This effect was most noticeable in the case of iron mullions of the tall office-building windows. These in many cases were bent several inches from a straight line, and in some cases these bends were veritable 'buckles' of the metal."

The writer of this account, like most other observers, noticed the "buckling" and "bending," but was, apparently, unaware of the fact that all of these cast-iron bars and frames had grown in cubic dimensions, and that it is this permanent growth which practically destroys the further usefulness of cast iron for such purpose after having been subjected to heat.

I regard the effects of the fire on cast iron in tall office buildings as a timely and valuable proof of the need of correct knowledge of these phenomena, which I have been studying for years, and have recently described in *The Journal of the Franklin Institute*.

ALEX. E. OUTERBRIDGE, JR.

PHILADELPHIA, March 8, 1904.

Notes and Comments.

STILL ANOTHER RADIUM PUZZLE.

What is becoming of our science of chemistry? Our century-old atomic conceptions have received a rude shock; the law of the conservation of energy, to which everything in this universe was supposed to be subservient, is attacked; and now we seem to be reverting to the dream of the medieval alchemist—actually thinking of the transmutation of metals.

This, at least, is what we have come to, after the announcement made by Sir William Ramsay that radium apparently changes to helium. When he compares the resultant product of radium with helium, Sir William Ramsay is sure of his ground; for in conjunction with Lord Rayleigh he carried on a series of classic experiments which ended in the discovery of argon and helium—a discovery which deserves to be considered one of the most noteworthy achievements in chemical physics of the nineteenth century. Sir William Ramsay caught the heavy gas which radium emanates, a gas so evanescent that it disappears after a time; he found that gradually its spectrum, entirely different from any hitherto recorded, displayed the characteristic yellow line of helium. Day by day the helium line grew brighter. In a word, one element seemed to have changed to another. It is quite necessary to know how fast radium is turned into helium. As yet little that is definite has been furnished. If nothing else occurs but the changing of radium into helium, then, Professor Ramsay figures, it will take 2,000,000 years to dissolve the gas.

Are we not perhaps on the verge of some great generalization, which will ultimately prove that just as we have many kinds of forces, all manifestations of one great force, so we may have seventy-odd elements, hitherto regarded as simple forms of matter distinct from each other, but in reality mere manifestations of but one matter? This strange, newly-discovered phenomenon

certainly tends to show that one element may be changed into another. "What is this?" asked Sir William Ramsay, "but an actual case of that transmutation of one element into another in which the ancient alchemists believed when they painfully sought to change lead into gold and incidentally founded the modern science of chemistry?"

Clearly, there are more things between heaven and earth than are dreamed of in our chemical philosophy.—*Scientific American*.

UTILIZATION OF BLAST FURNACE GASES.

For many years the fact has been realized that the blast furnace is practically a huge gas producer, and partial utilization of the fuel formerly wasted has been extensively practised in Great Britain and in other countries. More recently considerable progress has been made in utilizing blast-furnace gases by means of the internal combustion engine. As Mr. Humphreys showed in a recent paper, there were in operation at the end of the year 1902 fully 327 gas engines capable of developing an aggregate of more than 180,000 horse-power, and at the present time it is probable that the engines already built or in course of construction represent a total of some 220,000 to 230,000 horse-power, most of these engines being operated or intended to operate with furnace gas. In iron and steel works the waste gas is chiefly used for firing boilers supplying steam to steel plant, rolling mills and other machinery. The fact is now recognized that this is a roundabout method, and there is reason for believing that the continued improvement of large gas engines will ultimately render the use of steam unnecessary in large iron works. As an indication of movement in this direction we may mention the fact that the Buffalo works of the Lackawanna Steel Company are now being equipped with three new plants, one including eight 1,000 horse-power gas engines for driving dynamos, and two others having sixteen 2,000 horse-power engines for driving blowing engines.—*Scientific American Supplement*.

WASTE OF POWER.

The greatest waste of power in this country is found in the Connellsville coke region in Pennsylvania, where the gases from thousands of coke ovens pass off into the air. These gases might be used to operate gas engines and generate electric power, for which a market could be found in the busy districts, within an easy radius of transmission from the ovens.

STONEHENGE OFFERED TO THE ENGLISH GOVERNMENT.

Sir Edmund Antrobus has, through Lord Edmund Fitzmaurice, chairman of the County Council of Wiltshire, made a definite offer to sell Stonehenge and eight acres of land occupied by these magnificent Druidic ruins to the English Government for \$250,000, on the understanding that they will be preserved for the nation. Some years ago Sir Edmund made an offer to dispose of Stonehenge and twenty acres of the land on which the great stones stand

for \$750,000 to any one who was willing to pay that price, and great alarm was expressed lest some American multi-millionaire might purchase the celebrated megalithic monuments and carry them off to the United States. But this fear has not been realized. Sir Edmund's desire to get rid of Stonehenge is in no small measure due to the annoyance to which he has been subjected in the last few years in connection therewith. It was shortly after his accession to the baronetcy and estates on the death of his father in 1899 that he determined to surround Stonehenge, which forms part of his property, with a barbed-wire fence, and to charge an admission fee of 25 cents, his object being to protect the stones from the injurious treatment to which they were being subjected by people without any reverence for the hoary past. Moreover, as some of the stones were in danger of falling, he feared that in the event of anybody being injured thereby he might be held financially responsible. Exception, however, was taken to his attitude. It was said that inasmuch as Stonehenge had lain open to all the world since English history began, the public had acquired a right-of-way through every portion of the grounds on which the stones stood, and likewise a proprietary interest in the stones themselves. Then, too, it was pointed out that anything in the shape of a modern inclosure destroyed the spell created by the aspect of those immense stones standing alone in strange circles far from human habitation in the midst of a vast, open, rolling plain. And the result was that not only the general public, but likewise men of culture interested in the preservation of national monuments, raised a fund with the object of testing in the courts not Sir Edmund's proprietorship of the ruins, but his right to inclose them with a wire fence.—*Marquise de Fontenay in New York Tribune.*

HEIGHT OF THE SEA BREEZE.

Observations as to the height of the diurnal sea breeze are few in number, albeit of considerable importance. By means of a captive balloon, sent up from Coney Island a number of years ago, it was found that the average height at which the cool inflow from the ocean was replaced by the upper warm outflow from the land was from 500 to 600 feet. At Toulon, in 1893, the height of the sea breeze was found to be about 1,300 feet, and a distinct off-shore current was found between 1,900 and 2,000 feet. More recently (1902), on the west coast of Scotland, Dines, using kites, has noted that the kites would not rise above 1,500 feet on sunny afternoons, when the on-shore breeze was blowing.—*Quar. Jour. Roy. Met. Soc.*

ELECTRICITY DIRECT FROM CARBON.

Lorenz has published a summary of the present state of the problem of converting chemical energy of burning carbon directly into electricity. Slow combustion involved in the electrolytic process such as in an ordinary voltaic cell suffers under three disadvantages, viz.: the slowness of the reaction between carbon and oxygen at ordinary temperatures, the impurity of the carbon, which gives rise to complicated hydrocarbons in solution and the necessity of using the highly-priced conducting forms of carbon instead of ordinary coal. These circumstances lead to the adoption of a gaseous "electrode"

consisting of carbon monoxide, as in the cells of Bucherer and Borchers. In these, however, the currents obtained cannot be proved to result from the further oxidation of the carbon monoxide. Indeed, the existence of carbon monoxide ions has yet to be demonstrated. Another but more indirect way of utilizing the energy of carbon is that suggested by Nernst, in which carbon is used for regenerating other cells, such as a Daniell cell, by the reduction of the zinc sulphate. Another method proposed by Nernst is to heat an accumulator having a negative temperature coefficient until its e.m.f. disappears and then let it cool. Dolezalek has in fact obtained an e.m.f. of 0.6 volt between two lead accumulators having a difference of temperature of 90°. The problem is theoretically soluble, but will require much detail work for its final solution.—*Electrical World*.

Book Notices.

Encyclopedie des Aide-Memoire: Librairie Gauthier-Villars. Paris.

Since our last notice of this useful publication, the under-mentioned volumes of this series have reached us. Each individual member of the series is complete in itself, and treats, more or less elaborately, of some special subject of importance to the engineer. Small 8vo. (Price, 2 fr. 50c. in paper; 3 fr. in cardboard.)

Miron (François), Licencié ès sciences physiques, Ingénieur civil.—Gisements minéraux. Stratigraphie et composition.

Miron (François), Licencié ès sciences physiques, Ingénieur civil.—Les gisements miniers. Stratigraphie. Composition.

Morel (Marie-Auguste), Ingénieur, ancien Elève de l'École des Ponts et Chaussées, Licencié ès sciences mathématiques et physiques, directeur des usines à ciment Portland de Lumbres.—Les matériaux artificiels.

Colomer. Mise en valeur des gîtes minéraux.

W.

Report of the Commissioner of Education for the year 1902: Vol. I. 8vo, pp. cxii + 1176. Washington: Government Print. 1903.

The character and scope of the work of the National Bureau of Education can only be properly appreciated by an examination of the imposing volumes giving the results of its activity, which are issued yearly under its direction, and the wide range of topics which are covered.

W.

The Electrolysis of Water: Processes and applications. By Victor Engelhardt, Chief-engineer and Chemist of the Siemens & Halske Company, Ltd., Vienna. Authorized English translation by Joseph H. Richards, M.A., A.C., Ph.D., President of the American Electrochemical Society, etc. (With 90 figures and 15 tables in the text.) 8vo, x + 140 pp. Easton, Pa.: The Chemical Publishing Company. (Price: paper, \$1.00; cloth, \$1.25.)

This work has already been noticed in these pages in the original German. The present translation by Dr. Richards needs no encomium at our hands as to its accuracy.

W.

Howe's Hand-book of Parliamentary Usage. Arranged for the instantaneous use of legislative and mass meetings, clubs and professional orders, teachers, students, workmen and all who desire to conduct themselves "decently and in order" in public assemblies. By Frank William Howe. (12mo, pp. 84.) New York: Hinds & Noble. 1904. (Price, 50 cents.)

The specially useful feature of this hand-book is a revised arrangement of the whole subject-matter of parliamentary law, which should make it quite useful to the presiding officers of public meetings, and especially to those who may be inexperienced.

W.

Die für Technik und Praxis wichtigsten Physikalischen Grössen in Systematischer Darstellung. Die algebraische Bezeichnung der Grössen, Physikalische Masssysteme, Nomenklatur der Grössen und Masseinheiten. Von Dr. Olaf Linders, Maschinen- und Electro-Ingenieur. 8vo, pp. 396. (Mit 43 Textfiguren.) Leipzig: Verlag von Jäh & Schunke (Rosstergische Buchhandlung), 1904. (Price, Rm. 10.)

A work of this kind is always welcome to the investigator and student. It will be found especially elaborated in connection with the magnetic and electrical constants.

W.

The Optical Rotating Power of Organic Substances and Its Practical Applications. By Dr. Hans Landoldt, Professor of Chemistry in the University of Berlin; assisted by Dr. O. Schönrock, P. Linders, F. Schütt, L. Berndt, T. Posner. Second edition. Authorized English translation with additions by Dr. John H. Long, Professor of Chemistry in Northwestern University, Chicago. (Illustrated.) Easton, Pa.: The Chemical Publishing Company, 1902. (Price, \$7.50 net.)

The first edition of this standard work appeared in 1879. The present edition brings the subject up to date by the introduction of the work of van 't Hoff and LeBell. The book will be imperatively needed by chemical instructors and specialists in the field which it covers.

W.

Franklin Institute.

[*Proceedings of the stated meeting held Wednesday, March 16, 1904.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, March 16, 1904

MR. JOHN BIRKINBINE, President, in the chair.

Present, 184 members and visitors.

Additions to membership since last report, 6.

The Secretary reported that three vacancies existed in the Committee on Science and the Arts, caused by the death of Mr. Luther L. Cheney and the

resignations of Prof. Edgar Marburg and Mr. Clayton W. Pike. These were filled by the election of Mr. Wm. H. Thorne in place of Mr. Cheney; Mr. Richard L. Binder in place of Mr. Pike; and Mr. A. W. Allen in place of Professor Marburg. A letter was received from Mr. George V. Cresson, trustee of the Elliott Cresson Fund, announcing the death of Mr. S. Lloyd Wiegand, senior member of the trustees.

A special committee was appointed, consisting of Mr. H. R. Heyl (representing the Committee on Science and the Arts), Mr. James M. Dodge, (representing the Board of Managers) and Mr. A. E. Outerbridge, Jr. (representing the Institute at large), to report to the next stated meeting of the Institute the name (or names) of a suitable successor to fill the vacancy.

Mr. Julius F. Sachse, of Philadelphia, exhibited and commented on a series of lantern photographs, made from various historic sources, showing views of "Old Philadelphia." The collection, as a whole, is unique, and the exhibition was received with the approbation which the interest and importance of the collection justified.

Mr. C. C. Balderston, of Williams, Brown & Earle, Philadelphia, made some informal remarks on the subject of radium and other radio-active substances. He, likewise, exhibited some specimens of radium salts and several forms of apparatus in the treatment of diseases (cancerous growths and the like). He concluded his remarks by the exhibition of a series of radiographs, which showed in an instructive manner the relative transparency (or opacity) of a variety of substances (metals, glass, paper, rubber, etc.), to the radium rays. A comparison of radiographs of the same subjects, made by the action of the X-rays and radium rays, exhibited interesting differences. Interesting items of the exhibits were radiographs, apparently made from rays emanating from glass, rendered radio-active by having contained some radium salts, and from water rendered radio-active by the immersion therein of a glass tube containing radium salt.

Dr. John B. Shober also exhibited and described some interesting radiographs, showing instructively the comparative penetrating action of radium salts in various media.

The thanks of the meeting were tendered to the several speakers for their interesting contributions.

The meeting was closed by the exhibition of a fire-proof metal window and frame, made by Messrs. David Lipton Sons & Company of Philadelphia. The apparatus was described in detail, and its several novel features illustrated in operation.

Adjourned.

WM. H. WAHL,
Secretary.

Committee on Science and the Arts.

(Abstract of the proceedings of the stated meeting, held Wednesday, March 2, 1904.)

PROF. LEWIS M. HAUPT in the chair.

The following reports were considered:

(No. 2164.) *Steam Generator*. John C. Parker, Philadelphia.

This report is reserved for publication in full. The Elliott Cresson Medal is awarded to the inventor. (*Sub-Committee*.—Francis Head, Chairman; Chas. Day, Thos. P. Conard, J. M. Emanuel.)

(No. 2279.) *Electric "Buzz" Fan*. Dr. S. S. Wheeler.

Final action postponed.

(No. 2216.) *The Nernst Lamp*. Nernst Lamp Company, Pittsburg, Pa.

A provisional report, suggesting the continuation of the Sub-Committee until additional data can be collected. (*Sub-Committee*.—Arthur J. Rowland, Chairman.)

W.

Sections.

[Abstracts of stated meetings.]

MECHANICAL AND ENGINEERING SECTION.—*Stated Meeting*, held Thursday, February 25, 8 P.M. Present, 64 members and visitors. Mr. James Christie called the meeting to order, and requested Mr. Wm. Penn Evans to take the chair.

The paper of the evening was read by Mr. Henrik V. Loss, on "The Manufacture of Hydraulically Forged and Rolled Railway Steel Wheels." The speaker illustrated the subject by the exhibition of a 36-inch wheel made by this process, and by means of numerous lantern photographs showing details of the specially designed machinery employed, the successive steps in the operations of manufacture, the microstructure of the finished product, etc.

An extended discussion ensued. (This subject is referred for publication.)

The thanks of the meeting were extended to the speaker of the evening for his interesting communication.

The Executive Committee announced the appointment of Mr. G. H. Clamer as President of the Section for the year 1904.

D. EPPELSHEIMER, JR.,
Secretary.

MINING AND METALLURGICAL SECTION.—*Stated Meeting*, held Thursday, March 10, 8 P.M. President G. H. Clamer in the chair. Mr. H. A. Kimber, representing the Loomis-Pettibone Fuel Gas Company, of New York, read a paper on "Fuel Gas," illustrating the subject with the aid of a series of lantern photographs. The subject was freely discussed. The meeting passed a vote of thanks to the speaker of the evening, and adjourned.

WM. H. WAHL,
Secretary.

JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE PROMOTION OF THE MECHANIC ARTS.

VOL. CLVII, No. 5. 79TH YEAR. MAY, 1904

THE Franklin Institute is not responsible for the statements and opinions advanced by contributors to the *Journal*.

Savage and Civilized Dress.

BY EDWIN SWIFT BALCH,*
Member of the Institute.

The various material things placed by man on his body have a two-fold function: protection, ornament. Either they are intended to ward off the extraneous influences of heat and cold and humidity; to protect the feet from stones and wet, and the head and body from sun or blows or thorns; or else, as with jewelry, painting or tattooing, they are used with the idea of ornament, to make the person more beautiful. The idea of adornment, however, exists also to a certain degree in the garments put on for protection, and their shape and materials are often due to the dictates of that mysterious something known as fashion.

It might be assumed that the superior development of the brain of civilized man would result in some form of dress far better and more tasteful than anything found among savages, yet it may be doubted whether this is the

* Copyright 1904 by Edwin Swift Balch.

case to anything like the degree which might be expected. Even to-day in some places civilized man may obtain valuable hints from savage or semi-civilized peoples.

The garb of civilization was elaborated by races living in temperate zones, neither very hot nor very cold, and, therefore, it is primarily adapted to middle, not to extreme, temperatures. It was developed by the conditions of the environments in which the white races lived, and these conditions produced its advantages and its limitations, for it has been taken and not entirely successfully to both warmer and colder climes.

Of course, there can be no hard-and-fast laws about clothing. What is good in one place is bad in another; what is suitable for one person may be unsuited to his neighbor. Improved systems of reformed clothing may fail outside of their climatic limits. For instance, the all-wool system, for which so much has been claimed, is well enough for some persons in temperate latitudes in winter, but it is a burden to the flesh if the thermometer rises beyond a certain point, and, judging by the reports of many polar explorers, notably Dr. Kane * and Commander Peary,† it is inadequate for some persons at the other extreme.

The methods of covering the body used by savages are as a rule wonderfully adapted to meeting the demands of the climate and temperatures of the wearer's habitat. On account of the more or less precarious hand-to-mouth state in which savages live, and the difficulty with which they procure supplies with primitive weapons, they are forced to use the simplest means to make their clothing answer their needs, and, as might be expected, the savages exposed to cold climates have developed their garments mainly for protection, and those living in hot climates mainly for adornment.

For simplicity and protection combined, one of the most effective garments ever devised is the fur gown of the Mongol and Tatar races of Central Asia. Living on horseback

* "Arctic Explorations," Philadelphia, 1856.

† "Northward Over the Great Ice," New York, 1898.

on the high bleak steppes of the Gobi plateau, they had to devise something which would keep out the cold and yet be extremely simple. Their gown is really a long fur general-utility ulster. Pulled up and belted in at the waist, it does on horseback or on foot as a wrap, and the sleeves are long enough to cover the hands and act as gloves. At night the belt is loosened and the gown, which reaches to the feet, is sufficiently lengthy and warm to sleep in.

The bear, reindeer, seal and sea birds serve the peoples of the Arctic for their fashions as well as their menu. Yet so admirably have the northern tribes adapted their means to their ends, that Arctic explorers have learned many lessons from them. The Eskimo dress is so suitable to surrounding conditions that with but few changes it was practically adopted by the Peary expeditions. The Eskimo woman evolved bifurcated garments; very naturally, for how could anyone hampered with skirts wade through the snows of Smith Sound? Mr. F. G. Jackson* started on his journey to Siberia with a fur outfit made in London, but he soon discovered that the Samoyede furs were so much more intelligently cut for sledge traveling, that he threw away his London furs and used the native dress. As the result of his experience, Mr. Jackson† fitted out his party for Franz Josef Land with furs cut in London on the Samoyede pattern. These models have evidently come to stay, for one of the London equipment stores now advertises soviks, malitzas, loupthu and pimmies. Here, therefore, is a case where, within the last few years, the cut of the dress of savages has been found superior to and has replaced for certain purposes the garments thought out in civilization.

Another garment which civilized man has received from a semi-savage race is the putty. This was invented by the mountaineers of the Himálaya, and it is slowly spreading to all parts of the world. It is now a part of the British army uniform, and it was used by the English troops through the great Boer war. It is largely used by mountain climbers

* "The Great Frozen Land," London, 1895.

† "A Thousand Days in the Arctic," New York, 1899.

also, and it is stated that the weaving of putties has begun on a small scale in Switzerland.

The costumes of semi-civilized peoples are not always the best, however. The Highland kilt seems principally adapted to kill off the weaker specimens of the canny Scot. The Tyrolese costume, with its low shoes, footless stockings and black chamois knee-breeches, good enough though it is in the valleys, above the snow line is so impractical and so unprotecting that it is gradually giving way to the trouser, the knickerbocker and the laced boot. Yet four or five centuries ago at least the Tyrolese, when still practically uncivilized, invented the rucksack or back-bag, and this, by its superiority to every form of knapsack or haversack, is gradually superseding these among explorers and mountaineers.

When we turn to the inhabitants of the tropics, we find their dress or undress, as a rule, equally adapted to their necessities. Protection is much less thought of than adornment. Many of the races along the Equator go about without a scrap of clothing, and all they do to their persons is done with the idea of adornment. The Mashikulumbwe, for instance, according to Dr. Holub,* do no dressing beyond fixing up their wooly pates into a sort of upright queue 50 or 60 centimeters long. In fact, many of the savages of the tropics seem to have absolutely no idea of what clothes are made for. If an Australian black is presented with an overcoat, the chance is he will parade around in it all day in the sunshine and at night take it off and catch pneumonia in consequence. Humboldt† found a tribe of Indians on the Orinoco, to whom coats so thoroughly suggested ornament, that they actually painted blue jackets with black buttons on their bodies as a decoration.

The noteworthy point about the attitude of tropical races towards dress is that their lack of covering is probably the best arrangement for withstanding the circumstances of climate in which these non-dressing races live.

* "Seven Years in South Africa," London, 1881.

† "Personal Narrative," etc., Vol. IV.

Whether our clothing, an exotic from temperate climes, is healthier in the tropics for white men is a question, but there is some evidence that it is not so healthy for the natives. For instance, a British official reported that the introduction of trousers and shirts among the negroes of the Niger was a mistake, because formerly these men would jump into every stream for a bath, with the result that they were always clean, while now, on account of their clothes, they are hampered in this practice, and, having no idea of washing as we do, the result is they are dirty and malodorous. The Comte de Beauvoir* reports a case of a Dutch official in Java bringing up his son in native style, facing the sun with almost no clothes and without a hat, and when de Beauvoir saw the boy he was thriving and had escaped the diseases to which most European children in the tropics succumb. The Arab goes shoeless and wears a turban. Some Europeans of much experience in rough traveling, notably Sir Martin Conway,† consider the turban the best headgear in both hot and cold climates. Of course the turban was really evolved to keep out the rays of the sun, but the Arabs, who, perhaps, do not clearly understand the reason, have, according to Mr. Chanler,‡ a proverb directly the antithesis of ours, and that is, that if a man wishes to be healthy, he must keep his head warm and his feet cool. The South American Indians in the Brazilian forest wear no clothes, but daub their bodies all over with ochres and other earths as a safeguard against mosquito bites. A clever Frenchman, the Comte de Gabriac,§ who crossed South America, came to the conclusion that the costume of the Indians was made so necessary by circumstances that the most elegant Parisian traveling in the Brazilian forest would adopt it little by little; the heat first of all would force him to take off one article of dress after another, and when he had a dozen streams to cross in a day's

* "Voyage Autour du Monde," Paris, 1872, Vol. II.

† "The Alps from End to End," Westminster, 1895.

‡ "Through Jungle and Desert," New York and London, 1896.

§ "Promenade à Travers l'Amérique du Sud," Paris, 1868.

journey he would be obliged to undress entirely; finally, if he remained long in the country, de Gabriac thought "it would be an intelligent precaution on his part to cover his skin with substances suited to protect it from the execrable mosquitoes."

Nevertheless, some savage tribes of the tropics are but ill protected against their surrounding climatic conditions. The Touaregs, according to Mr. Harding King,* dress in thin black cotton garments. The color, of course, is the best absorbent of the sun's heat, and the material neither keeps out its rays nor the chill of the, sometimes, freezing nights of the Sahara. The force of fashion is well shown by a curious custom of this same people. The Touareg always keeps his face covered with a litham, a sort of mask; he lives in it, he sleeps in it, and when eating or drinking merely pulls it away from the lower part of his face and passes the food or cup up to his mouth from beneath it. The litham was undoubtedly originally intended as a protection against the sun and the scorching winds, and according to Sir Frederick Lugard,† especially against the impalpable dust of the Sahara, but the original use of this garment has been so forgotten through the abuse of custom that the Touareg now considers it immodest to show his face even to members of his own family.

Civilized peoples make mistakes in other ways. A point of hygienic importance in connection with clothing is the need of ventilation. The human animal breathes with his entire skin; refuse matter is thrown off as perspiration through every pore. Arrest this process entirely for a few hours and you kill the man; arrest it partially and you produce more or less sickness. The fact is well known, but in the garments of civilization it is almost universally unrecognized. It is only necessary to rip the lining of any coat to find the shoulders, chest and back padded with great wads of cotton, wool, horsehair and canvas, which hinder the escape of perspiration and prevent transpiration. Sim-

* "A Search for the Masked Tawareks," London, 1903.

† *The Geographical Journal*, London, Vol. XXIII, 1904, page 12.

ilar unhygienic results are obtained by lining waistcoats with canvas, by corsets, by the abuse of starch, and in other ways. My own experience in the matter may be, perhaps, worth mentioning. I used to suffer severely from rheumatism in the shoulder joints, but since wearing woolen suspenders, and having every bit of padding and interlining removed from my coats and waistcoats, I have been entirely free from the agonizing pains it caused. It may be added that I have never convinced any doctor that the matter was of medical importance. Savages, of course, know nothing about hygiene from any process of reasoning; but, owing to want of means and materials, they are unable to pad ventilation out of their clothes as we do, and fur-wearing tribes all divest themselves of their furs as much as possible in their tents and huts to let the perspiration dry off.

The principles underlying proper ventilation in garments are simple. The materials should be porous, and the more impervious materials should be inside. The ordinary modern bedding, first a sheet and then a blanket, is correct. Woolen clothes can be worn comfortably over woolen, cotton, silk or linen undergarments. Any one who will take the trouble to make a few experiments on himself will quickly discover that one cannot reverse the process without at least some disadvantage. A favorite plan now is to wear an all-woolen shirt under a cotton one. The woolen shirt has a tendency to overheat the wearer and put him in a perspiration, which is prevented from escaping by the cotton shirt, and the victim feels oppressed and uncomfortable without realizing that it is due to his own hygienic blunder. A number of polar explorers, de Gerlache,* Abruzzi,† and others, found woolen clothes more comfortable than furs, and Walter Wellman‡ stated the reason clearly in the following words: "Wool is far and away the best fabric for arctic wear. Even wool will gather moisture, but it is infinitely better than fur. Wool permits the

* "Quinze Mois dans l'Antarctique," Bruxelles, 1902.

† "On the 'Polar Star' in the Arctic Sea," New York and London, 1903.

‡ *McClure's Magazine*, Vol. XIV, April, 1900.

moisture of the body to pass through the fabric and congeal outside, where it can be brushed and shaken off, while furs retain it within. Two, three or more thicknesses of wool are better than one of equal weight."

Under the head of adornment must be classed various mutilations and injuries done to the human body. Some tribes of Indians compress the heads of babies to alter their shape; some African negroes introduce rings in the women's lips; some savages slash themselves and treat the wounds in such a way as to leave great welts; some tribes pull out or file into points their front teeth. These mutilations of the person are done either from some strange notion that they improve the appearance, or, as Dr. Donaldson Smith* found among the tribes of Lake Rudolph, to make the women so ugly that other more powerful tribes should not care to run away with them. In no case, however, do real savages mutilate themselves in such a way as to impair the full use of any portion of their bodies. The reason of this is, of course, because a maimed individual would have no chance in the struggle for existence under the conditions of hunting and nomad peoples.

With semi-civilized or civilized races, however, it is another story. The Hindoo fakirs find all sorts of ridiculous positions into which to twist and distort their bodies so as to render them useless. The Chinese crush the feet of girl babies into stumps, and consider this mutilation as a mark of birth and high rank. This curious custom probably had its origin in the desire to make women stay at home. It would never have been invented by hunters or nomads, as women who could not walk could not exist under the conditions of completely savage life.

Civilized peoples have achieved two deformities of the human body, both of which are practically unknown among savages. The first of these is the crushing in of the ribs and the displacement of the lungs and the abdomen, often caused in the female sex by the misuse of the corset and by tight lacing. The evils of this practice are universally

* "Through Unknown African Countries," London and New York, 1897.

known among medical men. Apparently such a custom is found among savages only in New Guinea, where Mr. Octavius C. Stone* saw *men*, not women, constricting their waists so tightly with a stiff bark belt, that in one case where the waist measured about 53 centimeters the flesh above and below it bulged out to about 70 centimeters.

The most curious deformity, however, achieved by civilized people is that produced in their feet by means of the civilized shoe. In the Middle Ages there was an iron instrument of legal torture called the boot, which, when put on and gradually made smaller, crushed the bones and flesh into a pulp. It seems to have been effective in its object of wringing any confession desired from the victim. In modern times the process is more gradual. It begins when the victims are tiny babies. Born in almost every case with feet as perfect as those of the Dying Gladiator or the Venus de Medici, babies have their feet gradually made into deformities by the shoes which the loving parents place upon them. Although the process is slower and less torturing than was the use of the boot in the Middle Ages, yet it is so rather in degree than in kind.

The strangest thing is that few persons seem aware of the irrationality of this. They are so used to deformed feet that a real deformity, where all the toes are jammed into a point, is considered a pretty foot, while a really natural foot is looked on as a deformity. Colonel Henry,† chief medical officer at Camp Black, in 1898, stated in an interview that a large proportion of the volunteers for the United States Army had to be rejected on account of imperfect feet, and if any one will look at the shoes worn until recently by the people in any large city of Europe or America, this statement will not seem surprising; everywhere are seen pointed toes and high heels. In the foot of a man who has never worn shoes, the four small toes go out straight and the great toe curves away from them a little, and leaves a space sometimes a centimeter wide between it and the other toes. In the civilized foot the great toe curves in towards the small

* "A Few Months in New Guinea," Harper & Brothers, New York, 1879.

† *The Sunday Times*, New York, June 5, 1898.

toes, generally touching them, and constantly this distortion is carried so far that the great toe is dislocated at the joint, forming a bunion. And a bunion is just as much a deformity as a humped back. Bunions are the main evil produced by the civilized shoe; but, of course, there are many minor ones, such as corns and ingrowing toe nails.

These pedal deformities may perhaps be assigned to two mental causes: ignorance and vanity. Scarcely any one realizes what an anatomically perfect foot looks like. Even modern sculptors not unusually give their statues deformed feet, a blunder not made by Greek or Japanese sculptors. People seem to have an inrooted belief that their feet look better in certain kinds of boots. They are not concerned as to whether the shoes conform to the shape of the foot and therefore as to whether they fit. A gentleman in painfully tight shoes told me "they looked neater," and a lady with a pair of fearfully deformed joints said, "I must sacrifice something to beauty." It need not be supposed that there is anything new about pointed toes and high heels, which apparently have an inborn attraction for Eurasian races. In Moscow are preserved a pair of boots belonging to one of the Tsars of about the year 1500 A.D. These are of emerald-green leather with small high heels and razor points in the middle of the toes; in fact, they would be ultra fashionable to-day.

High heels also are responsible for much ill carriage of the body, for they set the feet at an angle to the ground and therefore the knees must be slightly bent and the spine a little curved forward to give the proper equilibrium. Any one can prove this by experimenting with shoes with high heels and then with slippers without heels, in which it will be found that the back and legs immediately straighten out; in other words, that a more normal position is assumed. It is, however, a hopeful sign that modern shoemakers have begun to find out how to shape boots, for the sharp point is beginning to be placed more in front of the great toe.

Among savages neither high heels nor pointed toes, nor, indeed, any mode of deforming the feet, seem to exist. I have seen a good many semi-savages—Indians on the plains

and in Alaska, Eskimos in Canada, negroes in North Africa and Asiatics in the Russian Empire, and they have always had handsome, undeformed feet. I have searched in every way I could think of into the footgear of savages, among specimens in museums, in books, in drawings, in photographs, from all of which it appears that savages do not distort their feet. They wear sandals or moccasins or fur boots, but their footgear always conforms to, and does not have to be broken in by, the foot. The only specimens of the white races whose feet seem to remain undeformed are to be found among the poor dwellers in out-of-the-way districts, who habitually go barefoot. I remember a small fisher boy running over the tumuli at Locmariaquer, whose great toes curved away from the other toes, and, as he jumped from rock to rock, he caught on with a grip which resembled the prehensile qualities of the hands of monkeys. In out-of-the-way districts of Hungary and Croatia one may see hundreds of women barefoot. The older ones, those fifty or sixty years old, generally have beautiful feet; the younger ones, those twenty or thirty years old, mostly have enlarged joints. The explanation is simply that the older ones wear the native moccasin or slipper, which conforms to the foot, while the younger ones have adopted the civilized boot, which has been introduced within the present generation.

In regard to things purely ornamental, savages have certainly some queer customs, but so also have civilized peoples. Savages wear eagle or parrot feathers, but we wear ostrich feathers; savages place rings in their noses, but we place rings in our ears. Savages, however, have never invented the hair-destroying stove-pipe hat, nor the shapeless bags we call trousers, nor black dress suits, nor high collars, nor bustles, nor crinolines. A Hindoo gentleman recently accurately criticized our women's hats, when he spoke of them as curious straw baskets ornamented with dried grasses and dead birds. The latter practice is more barbarous than any fashion of savages, for we know, which savages do not, the indispensable value of birds to humanity in keeping down insects. In fact, our practice of destroying birds to use as ornaments is about as rational as would be an organized shooting down of policemen by law-abiding citizens.

If we look at savage and civilized dress from both the utilitarian and the artistic points of view, it does not seem as though civilized man had improved nearly so much on savage man as might have been expected, proving that here, at least, reason has but small influence as compared with instinct, custom and fashion.

COAL MINED BY MACHINES.

Characteristic of the age is the growing use of mine machines in the bituminous coal mines of the United States. The report of Mr. Edward W. Parker on the Production of Coal in 1902, which forms part of the annual volume of Mineral Resources, published by the United States Geological Survey, shows that 5,418 machines were employed in 1902 as against 2,622 in 1898.

In a few of the States there was a decided decrease in the number of machines used, but with the exception of Wyoming these were States in which comparatively little development in the mechanical production of coal has been made. All of the States where the use of machines had exerted any significant effect upon the production prior to 1902 showed substantial increase in that year.

Ohio claims the largest proportionate production by the use of machines, more than half the product of that State in 1902 having been machine-mined. Ohio also stands second in the total of machine-mined coal, Pennsylvania being first. Illinois ranks third in the amount of coal produced by machines, West Virginia fourth, Kentucky fifth, and Indiana sixth. It will be noted that these six States comprise the well-known "competitive" coal fields. In 1902 they produced 75 per cent. of the total output of bituminous coal in the United States and 94 per cent. of the total tonnage of machine-mined coal.

The total machine-mined product reported for 1902 was 69,611,582 short tons, an increase, as compared with 57,843,335 short tons in 1901, of 11,768,247 short tons, or 20 per cent. As the total production of bituminous coal in the United States in 1902 was 15 per cent. larger than in 1901, it will be seen that on the whole the production by the use of machines has more than kept pace with the increased output. In fact the percentage of the machine-mined product to the total output has increased from 26.68 in 1901 to 26.09 in 1902.

The statistics for 1902, as contained in the Survey's report, have all been obtained from the reports made to the Geological Survey by the coal-mine operators. It is possible that the falling off in machine production in some States has been due to the failure of operators to reply to this particular inquiry on the Survey schedules. Where no machines have been reported, it has been considered that none was in use, although the same mines may have reported the use of machines in 1901.

Of the 5,418 machines in use in 1902, 3,185 were of the "pick" or "puncher" type, 2,182 were chain-breast machines, and 51 were of the long-wall design.



HYDRAULIC FORGING PRESS.
 DRAWING FOR THE PATENT.
 SCALE: 1/2" = 1'-0"

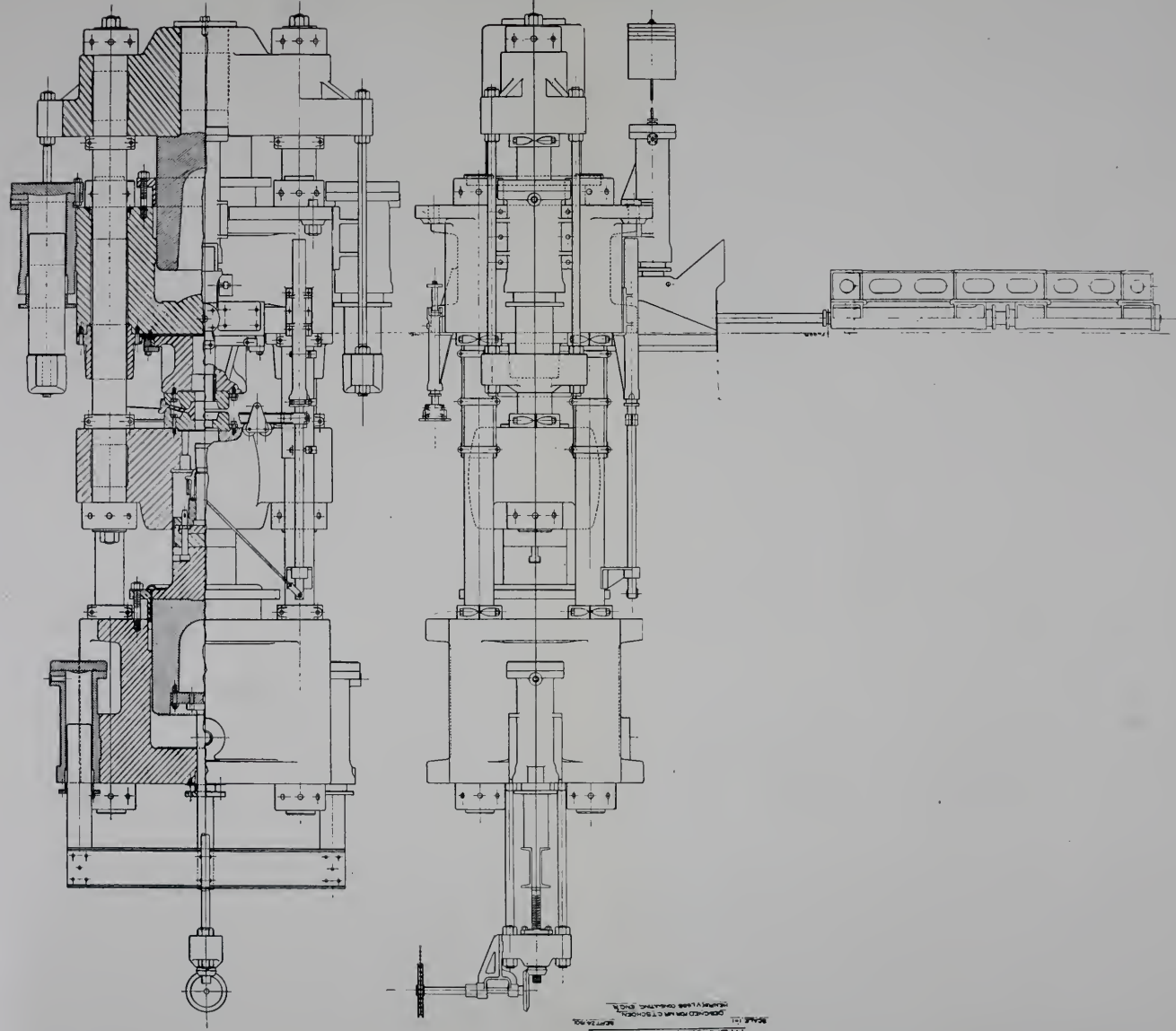
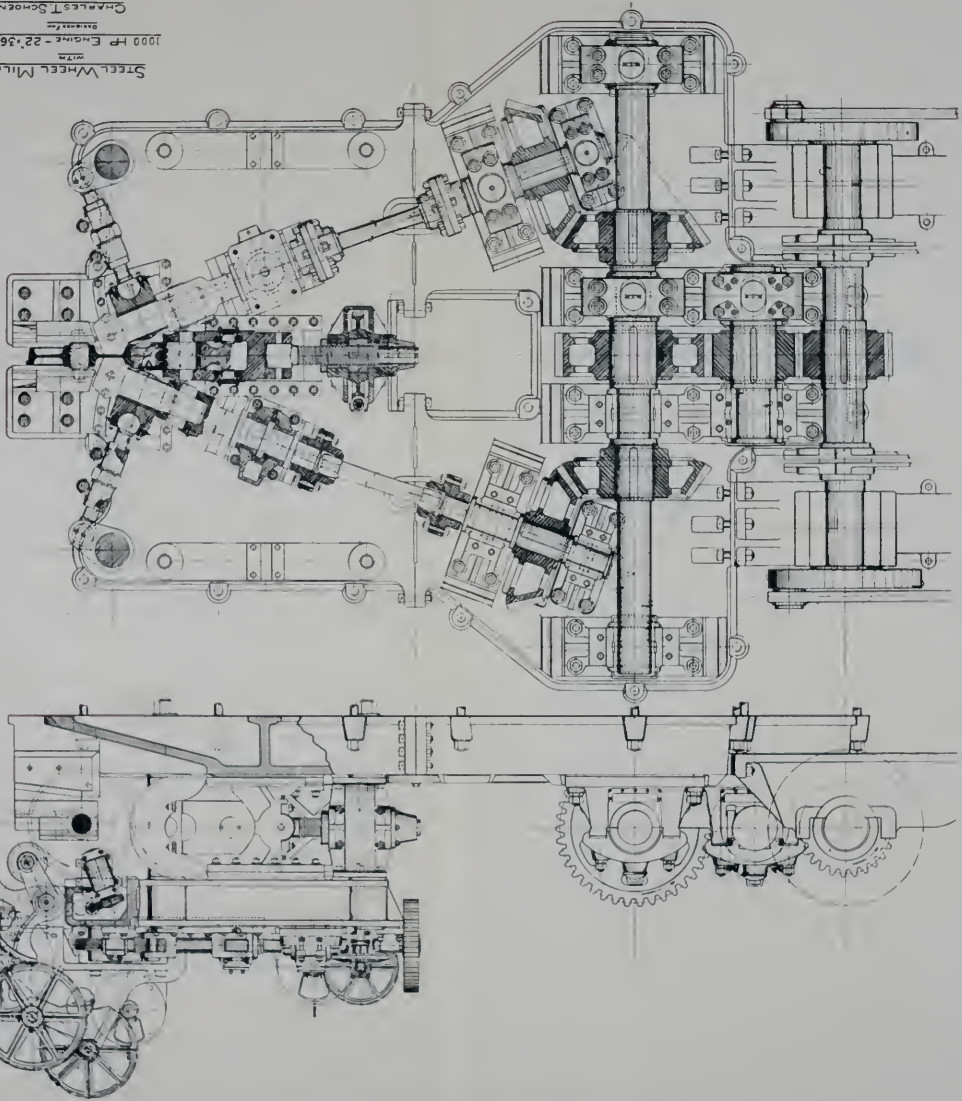


PLATE I.—5,000-ton Hydraulic Forging Press.



(Loss.)

four, Frank, Inst., Vol. CLVII, May, 1901.

Steel Wheel Mill
with
1000 HP Engine - 22.56 T
Schenck
Schwabe & Co. Schenck
Hermann V. Loss
Schenck & Co. Schenck
Schenck & Co. Schenck
Schenck & Co. Schenck

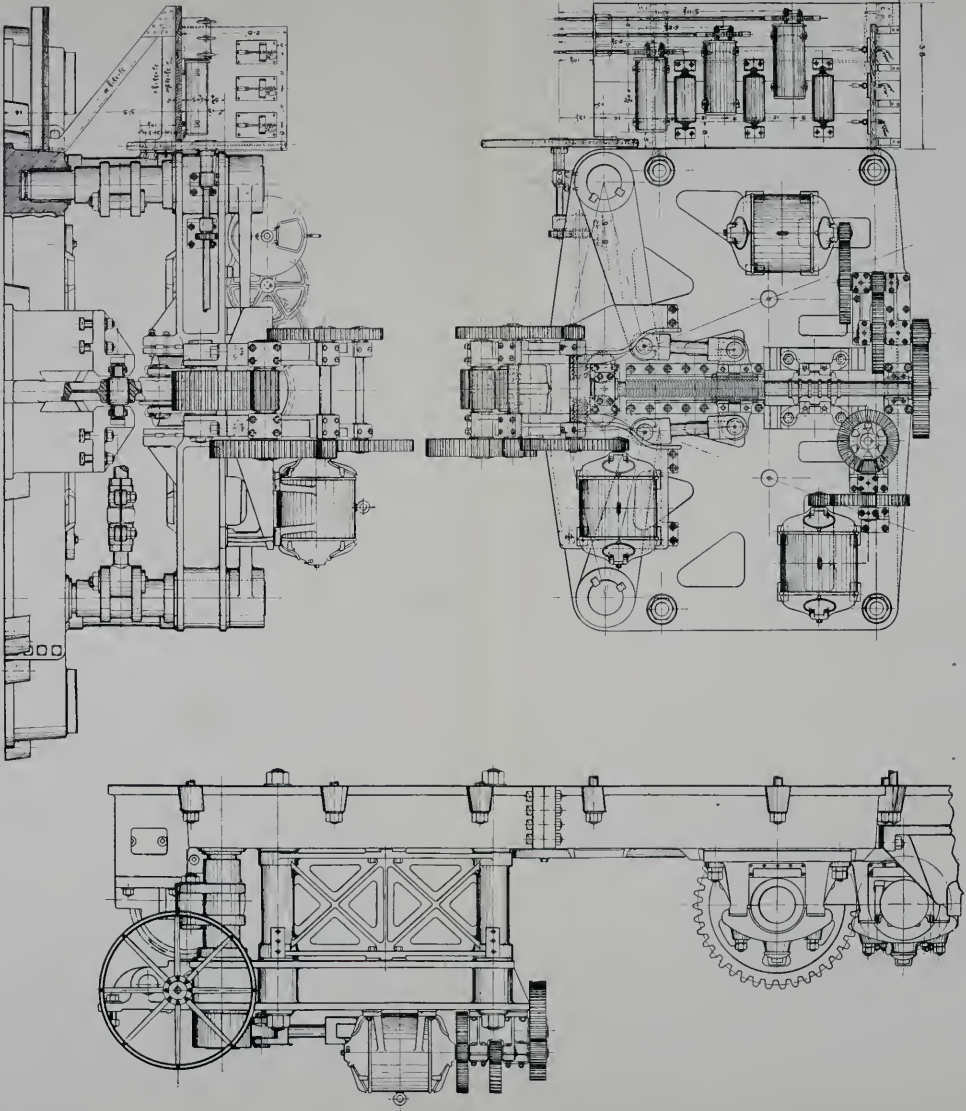


PLATE IIa.

Mechanical and Engineering Section.

Stated Meeting, held Thursday, February 25, 1904.

The Manufacture of Hydraulically Forged and Rolled Solid Steel Railway Wheels.

BY HENRIK V. VON Z. LOSS, M.E.,

Member of the Institute, Member American Society Mechanical Engineers.

Railway transportation, with its problems—road bed as well as rolling stock—has in later years claimed more than its share of capital and inventive thought, and as was naturally to be expected, in no other field of engineering have the undertakings been on as large a scale or of more practical and scientific interest to our profession.

It has been the speaker's fortune to have been associated with the development of the steel car, and, as his experience in this field has been somewhat extensive, the necessary results of the introduction of that car, and its technical requirements as to details, became early very apparent.

Immediately upon the introduction of the 100,000-pound car, the repair sheets of the different railways showed abnormal accounts, thus on the face of it tending greatly to eliminate the possibility of the adoption of this new innovation in transportation. A little investigation, however, proved that an unexpectedly large amount of the expense was caused by breakage of the wheels, and having no direct bearing upon the car structure proper.

That such should be the result was, after all, quite natural, when one considers that though the car capacities were but recently increased from 60,000 pounds up to 80,000 pounds, and finally up to 110,000 pounds, the substructure proper, which is represented by the wheels, was practically left untouched, barring the occasional adding of 50 to 100 pounds in weight, a heavy iron wheel of 33 inches diameter weighing to-day about 750 pounds.

It is also pertinent to recall, in this connection, that both the axle and the rail have been increased in large ratios to

sustain the increased duties. The swaying of the heavy steel car, in connection with its increased static load, proved, in many instances, ruinous to the flanges when passing switches or curves; and Mr. Schoen, the inventor and promoter of the steel car, suggested several years ago the possibility of applying a solid steel wheel, because of the fact that no additional weight or thickness could be given to the wheels at the spot where they most needed it, namely: at the root of the flange. In fact, the full economy of the large capacity steel car has never been realized, nor will it be until supported by a wheel, the flange of which will permit increased mileage with a practical elimination of wrecks. With this in view, all data and processes bearing upon the subject were investigated, and, about two years ago, the writer undertook to design for Mr. Schoen a plant to accomplish the purpose with a final result, the success of which is witnessed by the samples herewith shown to you, as well as by the wheels now being tried on the different railways; and again, as indicated by the photographs of the machinery and product which are attached to this paper.

The development of a perfect wheel is a matter of evolution. The first step in this series, after making the plain cast-iron wheel, was to make it with chilled tread. The next, in order to secure safety, was to make a steel tire and fit it to a wheel center. This style of wheel is now used almost exclusively throughout Europe, and to a considerable extent in the passenger service of this country; but, as there is a great deal of work expended in producing such a wheel, it naturally becomes very expensive. It appears that the ideal product should be made of steel of proper quality, all in one piece and forged and rolled to a perfect finish.

In order to make a successful steel wheel the balance sheet must again, first of all, be taken care of, and with this in view the price of such a wheel must be limited to a figure which shall bear a certain relation to the one of cast iron. In order to throw some light on the subject, the writer secured, a few years ago, some information from one of our leading railways, which will enable us to form an approximate opinion. It was found from two years' run, covering

5,320 cast-iron wheels (33 inches diameter and all legitimately worn out), in passenger service, that the average life per wheel was 56,000 miles. One hundred steel-tired wheels of the same diameter, and used in the same class of service, and similarly worn out, had an average mileage each of 265,000, or a ratio of 4.71 to 1 in favor of the steel wheel. Two hundred and sixty-five thousand miles is a very conservative estimate for steel wheels, because individual records of wheels show mileage as high as 380,000; showing what, under proper conditions, can be looked upon as a possibility.

Referring to the application of steel wheels for freight service, the railroad in question kept no records of the mileage for any wheel used in this branch of service; but with cast-iron wheels, the date of the wheel as cast upon it will give the desired information. During the same years 62,461 wheels, all legitimately worn out, were withdrawn from the service, representing an average age per wheel of eight years and three months. The average mileage per year of a freight car, as taken on the same railroad and during the same years, appeared to be 9,243. Multiply the average life of a wheel by the average yearly mileage of the car, and the result will give a fair approximate value of the average mileage per wheel for its entire life.

Pursuing this process, the average mileage of a cast-iron chilled wheel in freight service was found to be 76,260. There were no steel wheels used for freight purposes; but if we assume that the proportion between the life of a steel-tired wheel and a cast-iron chilled wheel remains the same, whether in passenger or freight service, the average life of a steel-tired wheel, under a freight car, would be 360,000 miles, or representing a life of over thirty-five years.

The above mileages are based upon the practice of the average wooden 60,000-pound car, and must be greatly modified when applied to the modern 55-ton structure. It has been stated by the representatives of one of the greatest freight-carrying railroads of the country, that the average mileage of a cast-iron wheel, when carrying the large capacity steel car, is about 35,000; and if we use this figure

as a basis, the life of a steel wheel should be in the neighborhood of 150,000 miles when based upon the data previously given. Using these two figures as a foundation for a financial comparison, the following data explains itself :

Assume as average service of cast-iron wheels (miles)	35,000
“ “ “ “ “ steel “ “	150,000
“ “ cost per wheel of cast-iron “	\$8 75
On this basis the cost of each 150,000 miles of service, with cast-iron wheels, would be	\$37 45
Less scrap value of about 4.25 cast wheels at 70 cents per hundredweight	17 98
Net cost for 150,000 miles with cast-iron wheels.	\$19 47

Adding to this last figure the value of a scrap steel wheel, which is about \$5, we find the allowable price for a wheel of this type to be \$24.47, not allowing for any other saving due to immunity from wrecks, as caused by defective cast-iron wheels, etc.

In the above it has also been assumed that the boring and mounting of the different cast-iron wheels is about equivalent to the “truing up” of the steel wheel.

Another point, which may be worth mentioning in this connection, is the fact that as the cast-iron wheel weighs at least 700 pounds, while the steel wheel weighs about 80 pounds less, there is a saving in dead weight per car of at least about 640 pounds.

The process as used in the manufacture of our new wheel is about as follows :

A round ingot, approximating in outlines the shape of a wheel, but of a quite smaller diameter and greater web thickness, is placed in a movable bottom die-holder of a 5,000-ton forging press; this machine being illustrated by Plate I, where the blank is first reduced in thickness. During this same stroke the hub is forged and finished and the hole punched—all in one operation. The original blank or ingot is about 4 inches less in diameter than the finished wheel, and its central body has a thickness of from 2 inches to $2\frac{1}{4}$ inches, which is reduced by rolling to a final web thickness of wheel of from $\frac{7}{8}$ inch to an inch.

Plates II and IIa represent the general drawing of the

mill, showing also part of the engine, while Plates III, IV, V, VI and VII are different views taken from the works recently erected in Pittsburg by Mr. Charles T. Schoen for the manufacture of the new wheel, and which represent the interior of the mill building with machinery and product, and also part of the power-house.

The forging press consists of a large bottom cylinder located below the floor, working through vertical, hollow-forged nickel steel 15-inch bolts on a movable cross-head, to which the top die is attached. The bottom die-holder is stationary from a vertical point of view; but is operated horizontally by a hydraulic cylinder, so as to facilitate the introduction of the blank and removal of the finished product. Above the forging cross-head with its top die, is located another large hydraulic cylinder in which works a piston, the lower end of which engages into the cross-head and is guided by the same. This piston performs two functions, viz., first, of punching the hole, after which the piston continues downward, coming to a stop inside the forging cross-head, adding its pressure to that already existing upon the top die, and hence finishing the hub under the combined pressure of the two rams, which amounts to about 5,000 tons. The punches are not stripped; but they are split automatically, leaving the lower half remaining in the wheel blank, and this is afterwards removed before going to the rolling-mill. Most of the mechanism is automatic, and hydraulic cranes are attached so as to minimize labor.

The two conical rolls of the rolling-mill are driven by a 1,000-horse-power engine, the general arrangement of which is all shown on the photographs. Electric alarms call the attention of the operator when the thickness of the web and the rim have reached their limit. The work of the actual rolling process consumes from one and one-half to two minutes.

The third and last step is the coning of the wheel, which is done in a separate 1,000-ton press that is provided with the proper dies and handling mechanism. In this machine the rim is pushed downwards so as to give the proper relation between the edge of the hub and the edge of the flange, and

it should be added here that this peculiar shape of the wheel furnishes a small degree of elasticity, which is beneficial under load.

The entire three processes are performed in one heat, and the transportation machinery, from furnace to press, from press to rolling-mill, and again from the rolling-mill to the last press, are all worked out so as to be as near as possible automatic, and will reduce the entire complement of workmen, including heaters and boys, down to about ten or twelve, this number also covering the men who are handling and distributing the cold blanks previous to charging.

Patents for all this machinery have been applied for throughout the leading countries of the world, and most of them have already been granted. The industry represents mechanical problems absolutely unique, and of great interest to the engineering fraternity.

It is readily seen that in designing the different tools which make up this process, as well as in selecting the process itself, the main mechanical point in view has been to put as much work on the material as possible, and, when referring to the rim, it is perfectly natural that, in order to secure a homogeneous metal in this part of the wheel, it is of interest not to have too much material congregated at that particular place. From financial reasons one would arrive at the same result; because when considering the long life of a steel wheel, the increased first cost, with its compound interest, due to the carrying of this additional thickness for a number of years, will tend to counteract whatever benefits might be derived by having a little longer life.

It must also be remembered, that as the wheel is a solid finite and self-contained structure, with the rim rigidly connected to the web, it is possible to run with a thickness of rim that would be absolutely prohibitory with a tire, because in this latter case such a thickness, not being backed up by anything but its own inherent strength, would be stretched by the rolling action and become loose on its center.

While on the subject of finance, we might also refer to the cost of the steel-tired wheel. It must be understood that

the great underlying purpose for the introduction of the solid steel wheel is not directly one of competition with the center and tire construction ; but is rather to be considered as a forward step in the freight trade. And with this in view, it is pertinent to say that should it even be impossible to claim the same amount of molecular work done on the metal, and also the same high excellence generally for the solid steel wheel as that which is claimed for the steel-tire construction, the difference, however, would be so small as to be of little account when considered in the light of the difference in the market prices of the two products.

In order to throw all possible light upon the effect on the metal as caused by this process of manufacture, and referring especially to the result of the kneading action in the rolling-mill, some experiments were made by Messrs. Williams, Brown & Earle, here in Philadelphia. A section of a wheel was given to the above firm to be highly polished, etched, magnified under a microscope and subsequently photographed. This magnification was about 50 to 1, and when making allowance for the magnification in the lantern the picture as thrown upon the screen will have been magnified in a ratio of about 1,500 to 1.

In order to form a better comparative opinion, pieces of the original and untreated blank were also investigated by the same concern and in a similar manner. The first two pictures, Plates VIII and IX, as thrown upon the screen, represent the original metal, the lighter being of a little denser structure than the darker one, though both show an entire absence of any uniformity or regularity in their molecular make-up. The next two, Plates X and XI, however, are taken from part of the rim of the finished wheel, and show a decided beneficial effect of the processes through which the wheel has passed. The last picture, Plate XII, is simply a photograph of the section which was treated as above, and as it was intended for mere experimental purposes it had never been coned, the web being left straight as it came from the mill. The tread shows cut marks where it was parted so as to furnish a smaller piece to facilitate handling in the microscopical and photographic apparatuses.

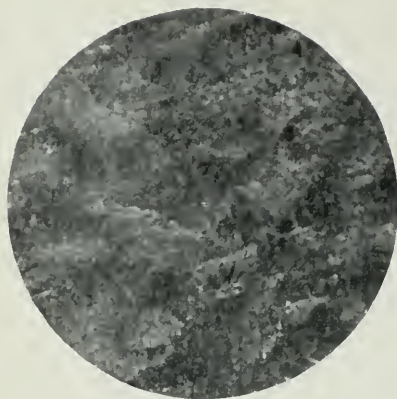


PLATE VIII.

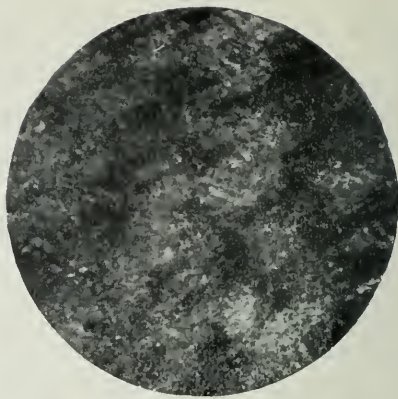


PLATE IX.



PLATE X.



PLATE XI.



PLATE XII.

If it is of great importance to have a maximum amount of work done on the metal, it is even still more necessary to have a metal of the proper chemical composition. With this in view, inquiries were made in the engineering department of a large trunk line to ascertain which composition of tire produced the best result, realizing what was good for a tire would naturally be equally good for a solid steel wheel.

The mileage of several compositions were given, and the comparison between them resulted in a metal which is our present standard, and which runs about as follows:

Carbon	about '7	per cent.
Manganese	'65 to '70	" "
Silicon	'3	" "
Sulphur and phosphorus, both below	'05	" "

The physical test showed an elongation of about 13 per cent. in 2 inches, with a contraction of about 35 to 40 per cent., and an ultimate of about 125,000 pounds per square inch.

It may be of interest to know the practices in this line of foreign railways, and with that in view I have copied the following specifications from a trade catalogue published by one of the leading makers of steel tires:

ENGLISH PRACTICE.

CHEMICAL ANALYSIS.

Carbon	'65 to '75	per cent.
Silicon	'20 to '25	" "
Phosphorus	under '05	" "
Manganese	'50 to '55	" "
Sulphur	under '045	" "

PHYSICAL TEST OF STEEL OF ABOVE ANALYSIS.

Tensile strength	115,000 to 125,000	pounds.
Elastic limit	55,000 to 60,000	" "
Elongation	10 to 15	per cent.

RUSSIAN PRACTICE.

CHEMICAL ANALYSIS OF STEEL.

Carbon	'50 to '60	per cent.
Phosphorus	under '05	" "
Silicon	under '25	" "
Manganese	'50 to '70	" "
Sulphur	under '05	" "

PHYSICAL TEST OF STEEL OF ABOVE ANALYSIS.

Tensile strength	85,000 to 100,000 pounds.
Elastic limit	45,000 to 50,000 "
Elongation in 2 inches	17 to 22 per cent.

JAPANESE PRACTICE.

CHEMICAL ANALYSIS OF STEEL.

Carbon	'55 to '65 per cent.
Silicon	under '20 " "
Phosphorus	under '05 " "
Manganese	'55 to '65 " "
Sulphur	under '045 " "

PHYSICAL TEST FROM STEEL OF ABOVE ANALYSIS.

Tensile strength	100,000 to 107,500 pounds.
Elastic limit	50,000 to 55,000 "
Contraction of area	20 to 29 per cent.
Elongation in 2-inch section	15 to 18 " "

FINLAND STATE RAILWAYS.

CHEMICAL ANALYSIS.

Carbon	'50 to '60 per cent.
Silicon	under '20 " "
Phosphorus	under '045 " "
Manganese	'50 to '60 " "
Sulphur	under '045 " "

PHYSICAL TEST FROM STEEL OF ABOVE ANALYSIS.

Tensile strength	92,000 to 100,000 pounds.
Elastic limit	46,000 to 55,000 "
Elongation in 8 inches	15 to 18½ per cent.

Since the commencement of the agitation in favor of a solid forged, rolled steel wheel, the makers of the old cast-iron chilled product are brought face to face with a new innovation, and many arguments in favor of their own wheel and objections to this new one were advanced. It has been said that the introduction of the new steel wheel would force railroads to purchase and operate lathes to an extent that would be prohibitory in order to keep the steel wheel up to its standard. If the life of a steel wheel, with all its turnings, were no greater than the life of a cast-iron wheel, such arguments would be true. But if the time between the turnings of the steel wheel represents a mileage equal to that of a cast-iron wheel—and which it should do—

there would be no more dismantlings than what at present exists in ordinary car practice.

The above statement is based upon cast-wheel mileages of 70,000; but, as previously mentioned, the experience of at least one of the great trunk lines has cut this figure down to from 30,000 to 40,000 miles when operated in connection with the 100,000-pound cars, and in such a light the dismantlings for the steel wheel are of still less importance.

It has also been argued that good cast iron represents a metal for wheel purposes which is superior to steel, as it flakes less and, barring the question of strength, is a better all round metal when provided with a chilled rim.

I am not here to belittle the merits of the cast-iron wheel; on the contrary, its introduction, with its many magnificent qualities, enabled industrial progress to an untold degree; but, unfortunately, as competition became greater less care was used in the selection of the iron, and instead of having a metal of charcoal material, with an ultimate resistance of from 30,000 to 33,000 pounds, the wheels of to-day are made of iron ranging between 20,000 and 22,000, and at times hardly that. Such is the fact independent of any theory, and it is with this low-grade wheel that we have to deal.

I do not deny that it may properly be asked: If a better cast iron were substituted, what would be the result? The most pertinent reply that can be given to this query is, that all would have been well and the steel wheel would not have become a necessity, if the world had not seen the introduction of the steel car.

It goes without saying that when frogs and switches actually prohibit the increase of dimensions only one other alternative exists, namely: increase of tensile strength; and this last step in the evolution of the car wheel became, hence, a necessity and, as I also trust, has now become an accomplished fact.

Barring the records of individual railways, no concerted action has been taken in this country to keep and maintain a national record of the life and accidents to railway wheels. In Germany, however, an association was formed about ten

to fifteen years ago which included the German State Railways, the Austrian-Hungarian State Railways and a few other independent roads. This association has taken a great deal of care in the matter of wheels, comparing damages to different constructions as well as to different metals. There are, of course, no rolled steel wheels in their territory; but a number of cars, with a few locomotives and tenders, have been equipped with solid cast-steel wheels, and it is interesting to note the results, though their number is somewhat too small to form very conclusive opinions as to details.

During the years 1887 to 1896, the total number of tired wheels varied from 1,700,000 to 2,300,000, while the total number of solid steel wheels commenced at 340,000 and increased to 375,000, most of which latter were, as already mentioned, placed under cars generally carrying freight.

It was found that the percentage of loss—this includes cracks and fractures—in the steel-tired wheels was about .18 per cent. in 1892, increasing up to .22 per cent. in 1894 and 1895, while with the solid steel wheels during the same period, the total loss was about one-half of 1 per cent. In steel-tired wheels the relation of cracks to fractures was about 7 to 10, while with solid wheels the fractures were so rare that as a matter of comparison they can be ignored.

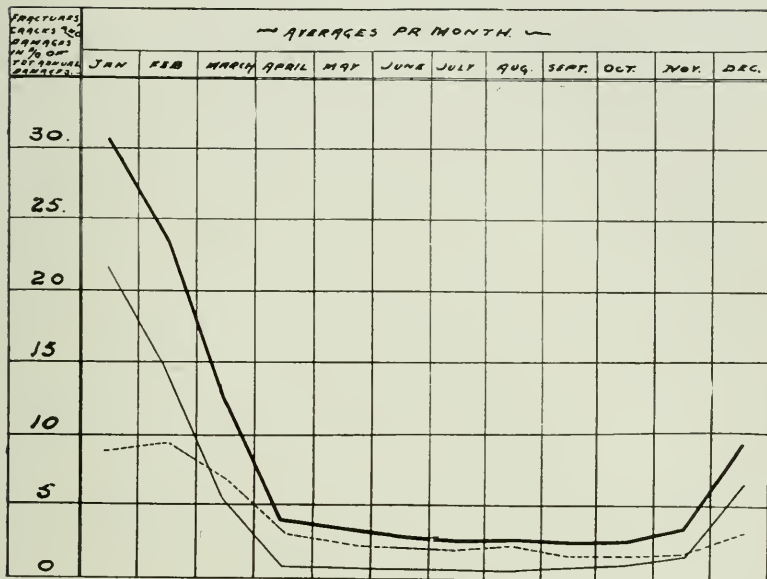
The above indicates clearly, from a point of general result, the superiority of the forged and rolled rim as compared to that of the coarse, crystalline cast metal.

The German report furnished some data on the question of temperature which may be of interest to our profession in this country.

The total damage done to steel-tired wheels during any one summer month, as compared to the month of January, is one to ten. This heavy mid-winter destruction lasts only for a short time, reaching its maximum during the month of January, while during the five summer months the minimum will remain practically constant. With solid steel wheels this relation was as one to four, showing the beneficial result of a solid web.

The German data indicated that the maximum damage

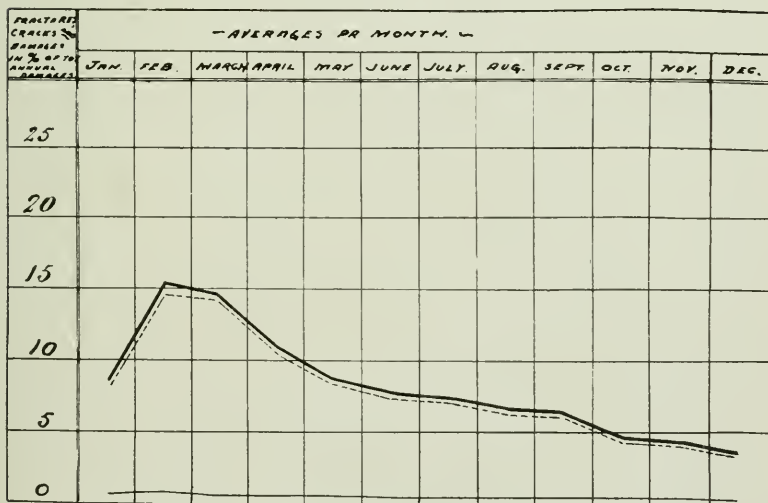
~ STEEL TIED WHEELS. ~



— FRACTURES. —
 - - - - - CRACKS. —
 — DAMAGES = FRACTURES + CRACKS. —

PLATE XIII.

~ SOLID CAST STEEL WHEELS. ~



— FRACTURES. —
 - - - - - CRACKS. —
 — DAMAGES = FRACTURES + CRACKS. —

PLATE XIV.

~ Theoretical Diagram of a forged and rolled Steel Wheel. ~

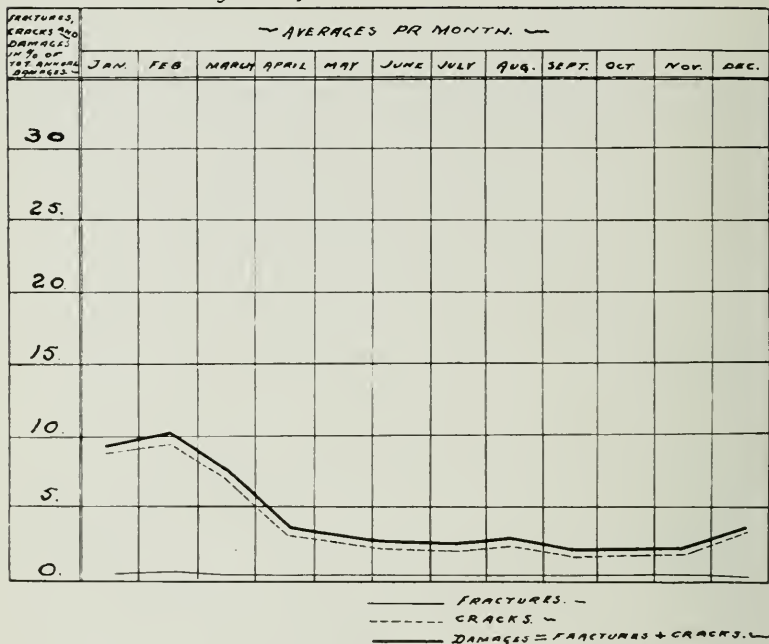


PLATE XV.

Diagram showing Comparison between Cast Steel, Steel Tired and Rolled Steel Wheels. ~

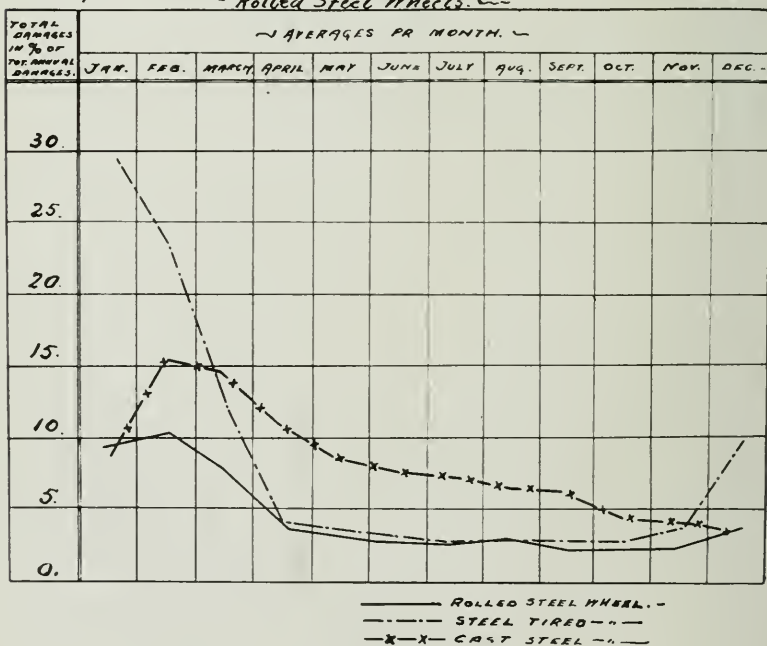


PLATE XVI.

was done with heavy tires, which I naturally suppose means that if a tire is imperfect the defects will develop shortly upon the wheel being placed upon the road. Illustrating this point, the following figures give a very interesting summary (the total damage done being considered as 100 per cent., including fractures and cracks, and the wheels representing the sum of both types, cast steel as well as tired).

Six per cent. of all the damage was done on mileages above 190,000; 30 per cent. was done on mileages between 100,000 and 190,000; 23 per cent. was done on mileages between 70,000 and 100,000, and 25 per cent. was done on mileages between 35,000 and 70,000.

The lessons derived from the above data, and as taught us by our German fellow engineers, would certainly seem to warrant us in drawing the conclusion that the solid forged and rolled steel wheel would have a rim which should possess very many of the meritorious qualifications of the steel tire, coupled with the advantages and the inherent strength afforded and shown by the web of the solid cast-steel structure.

The diagrams shown on Plates XIII, XIV, XV and XVI illustrate graphically what already has been said regarding temperature and wheel damages, cracks and fractures being shown separately.

The two first cards give directly the German results for steel-tired and cast-steel wheels, while the third card, representing the rolled steel wheel, is a theoretical construction based upon the German data for fractures with the cast steel wheel, and cracks with the steel-tired type. Such a combination ought to be one which this new construction should closely approximate.

The fourth card shows the total damages for all three kinds of wheels, and it is seen here that the solid wheel with the rolled rim shows the best efficiency.

In the history of the world industrial progress has been emphasized by certain landmarks, and I believe that among these epoch-making events those that refer to transportation on water or land are the greatest of all.

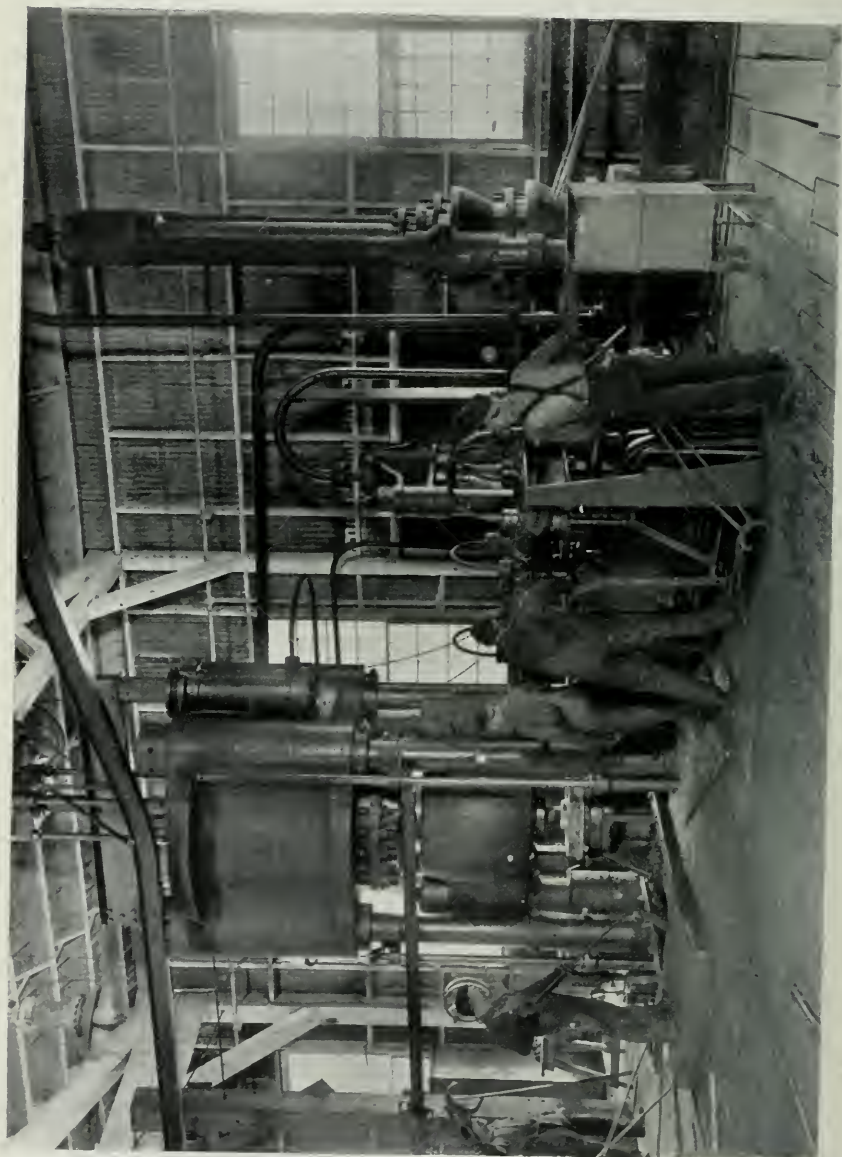


PLATE III.

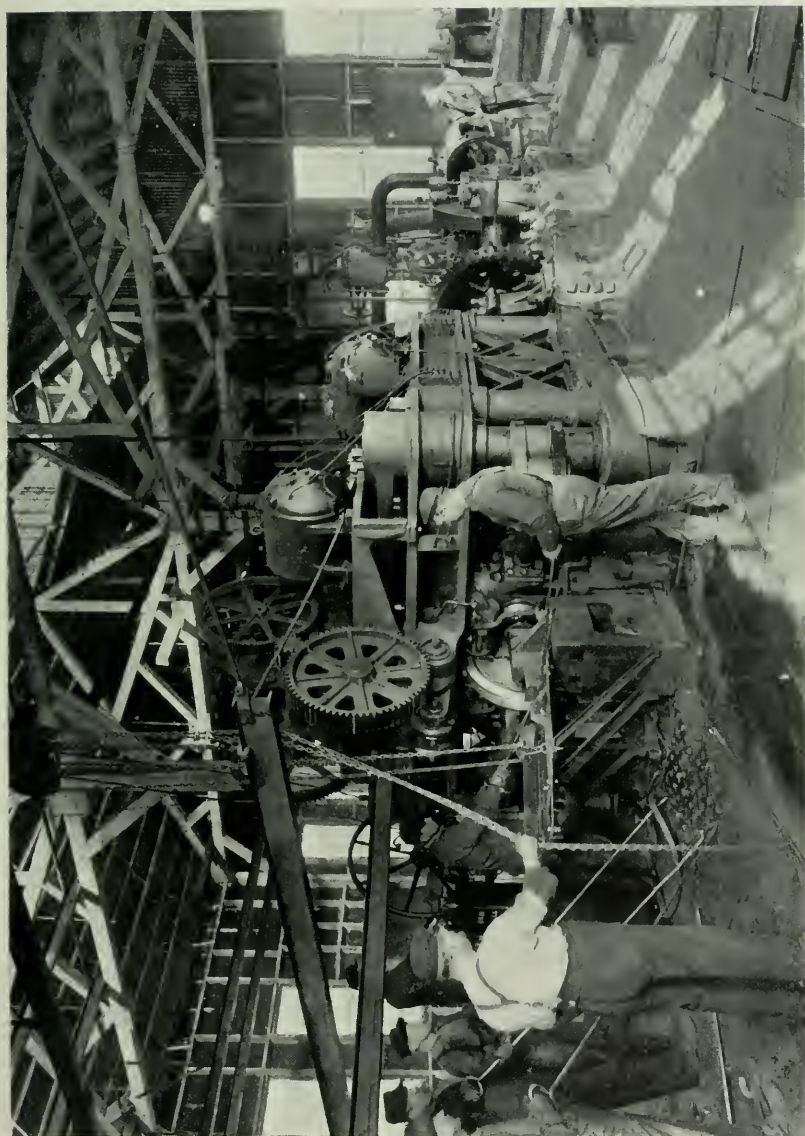


PLATE IV.

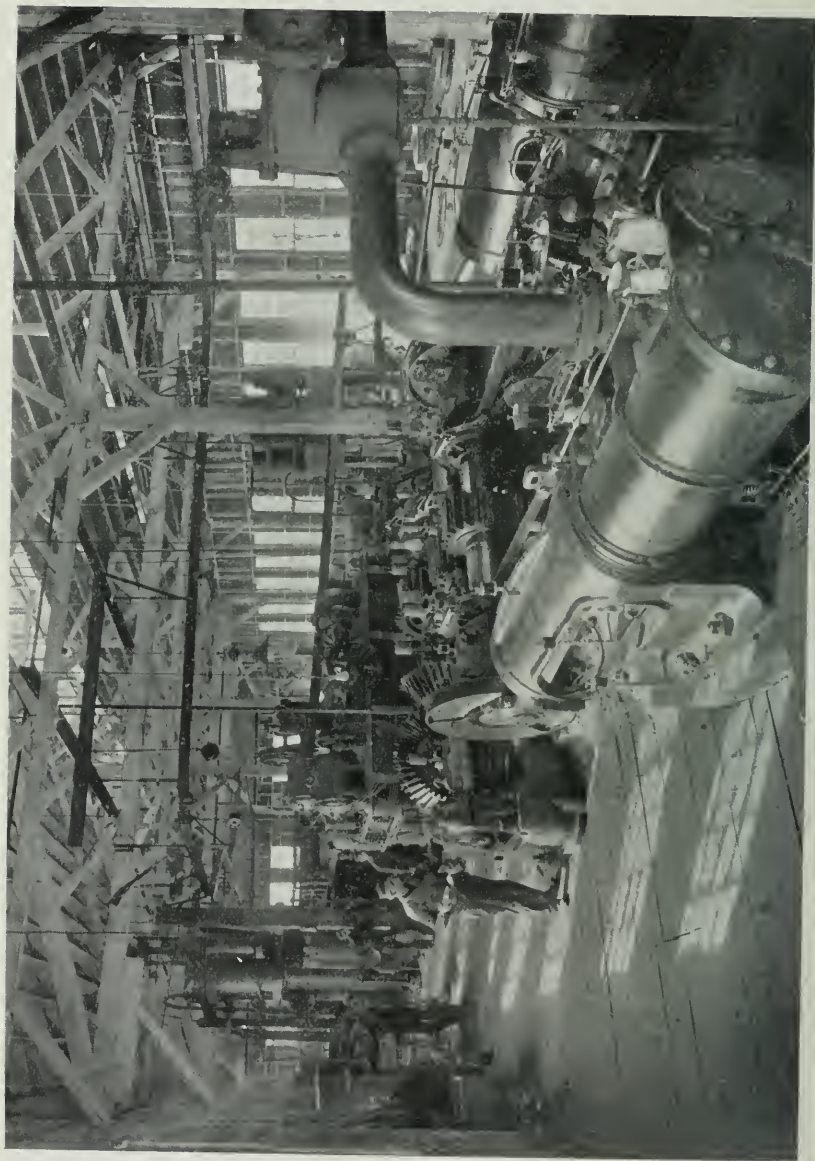


PLATE V.

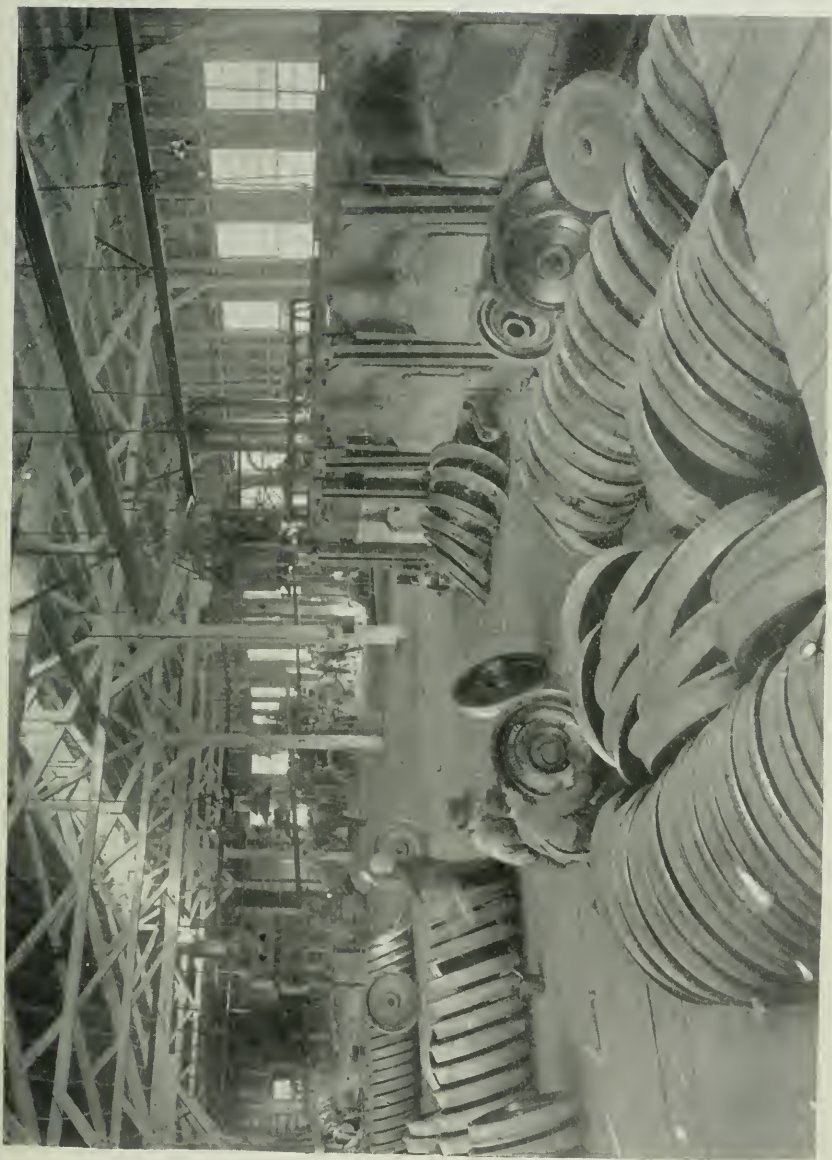


PLATE VI.

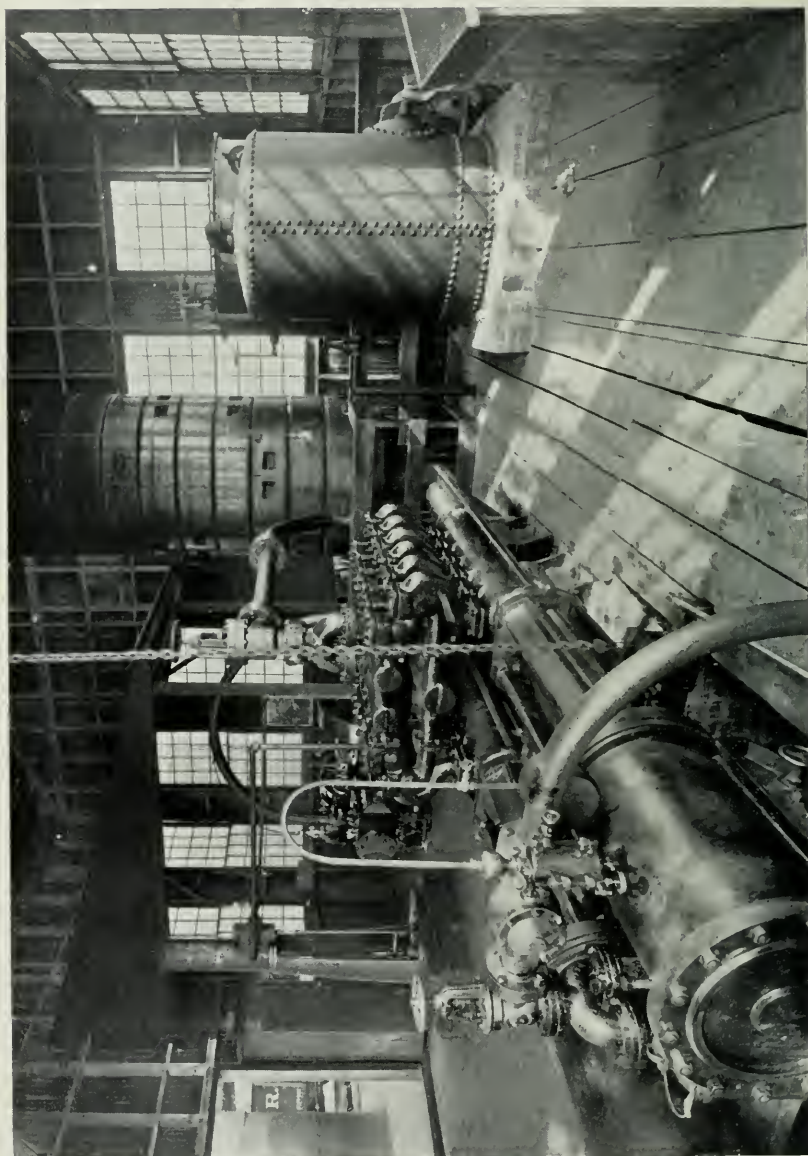


PLATE VII.

A few years ago, at a festive gathering of a number of remarkably able men, the question arose as to the relative importance, financially, industrially as well as ethically, of the leading inventions and discoveries recorded in the annals of history. The mariner's compass, the printing press, the steam engine, the laws for movement of matter, the discovery of the blood circulation, the anæsthetics, etc., were all reported in due order. The host, who was president of one of the greatest trunk lines of the world, remained silent. Finally, when one of his guests addressed him with a request to mention *his* choice amongst the great meritorious facts, his answer was prompt—"the flange of a car wheel."

DISCUSSION.

MR. ARTHUR FALKENAU:—I should like to know from Mr. Loss of what kind of material the punches are made.

MR. LOSS:—After a number of experiments we decided in favor of fairly hard cast iron as possessing the best average combination of durability and cheapness.

MR. W. VOLLMER:—I should like to ask Mr. Loss about the number of wheels at present in service. Also about their length of service and the mileage covered as well as their general efficiency.

MR. LOSS:—Last June about thirty experimental wheels were placed under locomotive tenders on different railways and for different purposes. Fast express trains, accommodation passenger trains (some of these latter running on mountain roads) and heavy freight were all included. From 25,000 to 35,000 miles, depending upon the character of service, was the average mileage before turning, and the general wear as taken from plaster casts was very good. The master mechanics handling the wheels have informed me that their behavior on the road or in the lathe in the machine shop was the same as that of an ordinary steel-tired wheel. We have lately started our works in Pittsburgh, and during the last month from 900 to 1,200 additional wheels have been shipped and are daily being placed on the different roads.

MR. E. B. HALSEY:—What is the percentage of carbon used in the steel, and do you start from a blank or from blocks of steel cut from the ingot?

MR. LOSS:—The percentage of carbon is about .70, and the ingots are, as previously described, at present run separately. They are round, with varying thicknesses, and there is no doubt but what we shall shortly run them in multiples. Not being a mere steel casting, we use no sink-heads, but fall back upon the great pressures exerted upon the metal in the two presses and the rolling mill to solidify it. The pressure on the rim while rolled is equal to that existing in the largest tire-mill of to-day. The microscopic photographs show how well we have succeeded. It must be added, however, that a great deal of time and expense were bestowed on the subject of how to cast the ingots, resulting in the adoption of some very interesting methods. Our uniformity in product has been greatly advanced by this knowledge.

PRODUCTION OF ALUMINUM IN THE UNITED STATES IN 1902.

The production of aluminum in the United States during 1902 was approximately 7,300,000 pounds, as compared with 7,150,000 pounds in 1901, an increase of 150,000 pounds according to a report on the production of that metal by the United States Geological Survey. The Pittsburg Reduction Company, operating the Hall patents, continues to be the sole producer of aluminum in the United States, and, although the company is in patent litigation with the Cowles Electric and Smelting Aluminum Company, of Cleveland, its plants are being developed vigorously. It has in operation 11,000 horse-power at Shawinigan Falls, Quebec, a total of 16,000 horse-power, which is equivalent to a capacity of 4,500 tons of metal yearly, or more than the entire output of the rest of the world. The increased activity on the part of the company has been due to the fact that some of its fundamental patents will expire within a few years, and it is striving to perfect the methods employed to such an extent that after the expiration of the patents it will be in a position to compete successfully with new producers that may enter the field. Although the demand for aluminum has increased extensively, the price per pound continued practically stationary throughout the years 1901 and 1902. An international agreement between all of the aluminum producers has been drawn up and the price of ingot aluminum fixed for 1903, says the report. There are five companies in the world that produce aluminum at nine locations. For several years past the various companies have continued their secretive policy concerning the development of the industry, and practically nothing has been published in regard to modern improvements beyond the descriptions of patents, which have been granted mainly for the purification of bauxite—the chief raw material used in the manufacture of the metal.

CHEMICAL SECTION.

Stated Meeting, held Thursday, March 12, 1904.

Lutes.

BY SAMUEL S. SADTLER.

The subject of plastic cements used to secure joints in vessels and connections (generally for temporary purposes), has been rather neglected in the chemical literature.

The success or failure of processes has very seldom depended upon the choice of satisfactory lutes, but great annoyance has been experienced in chemical works and manufacturing places where only unsuitable compounds have been found to seal apertures in nitric acid, chlorine, hydrogen sulphide and illuminating gas apparatus, and frequently considerable damage to property and loss of life has resulted.

I have, therefore, thought it advisable to bring together under the one title such formulæ as I know to be reliable, or have reasonable grounds for believing so, and hope they may be useful to others for laboratory or works' use.

The majority of these cements are useful for purposes of preventing the escape of inert gases, and others are suitable for more or less special purposes, where corrosive gases, etc., come in contact with them. Many of them had to be put down from memory, and therefore the product obtained in their use may be a little too stiff or too thin, but such deficiencies could be easily regulated.

Lutes always consist of a menstruum and dissolved or suspended solids, and they must not be attacked by the gases and liquids coming in contact with them. In some cases the constituents of the lute react to form a more strongly adhering mass.

The *conditions of application* are, in brief:

(a) Heating the composition to make it plastic until firmly fixed in place.

(b) Heating the surfaces.

(c) Applying the lute with water or a volatile solvent, which is allowed to volatilize.

(d) Moistening the surfaces with water, oil, etc. (the menstruum of the lute itself).

(e) Applying the lute in workable condition and the setting taking place by chemical reactions.

(f) Setting by hydration.

(g) Setting by oxidation.

These principles will be found to cover nearly all cases.

Joints should not be ill fitting, depending upon the lute to do what the pipes or other parts of the apparatus should do. In most cases one part of the fitting should overlap the other so as to make a small amount of the lute effective and to keep the parts of the apparatus rigid, as a luted joint is not supposed to be a particularly strong one, but rather one quickly applied, effective while in place and easily removed.

Very moderate amounts of the lute should be used, as large amounts are likely to develop cracks, be rubbed off, etc.

A classification may be given as follows :

- | | |
|------------------------|---|
| (1) Plaster of Paris. | (8) Linseed oil. |
| (2) Hydraulic cement. | (9) Casein and albumen. |
| (3) Clay. | (10) Silicates of soda and oxychloride cements. |
| (4) Lime. | (11) Flour and starch. |
| (5) Asphalt and pitch. | (12) Miscellaneous, including core compounds. |
| (6) Resin. | |
| (7) Rubber. | |

I. PLASTER OF PARIS

is, of course, often used alone as a paste, which quickly solidifies, for gas and wood distillation retorts, etc., and similar places where quickness of setting is requisite. It is more often, however, used with some fibrous material to give it greater strength. Asbestos is the most commonly used material of these, as it will stand a high temperature. When that is not so important, straw, plush trimmings, hair, etc., are used as binders, while broken stone, glass and various mineral substances are used as fillers, but they do not add anything to the strength. These lutes seem to be particularly suitable for oil vapors and hydrocarbon gases.

Formulæ : (1) Plaster and water.

- (2) " (wet) and asbestos.
- (3) " " " straw.
- (4) " " " plush trimmings.
- (5) " " " hair.
- (6) " " broken stone, etc.

II. HYDRAULIC CEMENT.

Cement is used either alone or with sand, asbestos, etc., and I have been informed that these lutes are suitable for nitric acid. When used with substances such as resin or sulphur, it is probably employed because it is in such a fine state of division and used as a filler and not because of any powers of setting by hydration.

Formulæ : (1) Cement—neat.

- (2) " and asbestos.
- (3) " and sand.

III. CLAY.

This most frequently enters into the composition of lutes as a filler, but even then the very finely divided condition of certain grades renders it valuable, as it gives body to a liquid, such as linseed oil, which, unless stiffened, would be pervious to a gas, the clay in all cases being neutral. Thus, for luting pipes carrying chlorine, a stiff paste of clay and molasses has been suggested by Theo. Köller in *Die Surrogate*, but I cannot recommend it, as it soon gives way.

Formulæ : (1) Clay and linseed oil.

- (2) Same using fire-clay.
- (3) Clay and molasses.
 - (1) Is suitable for steam, etc.
 - (2) For chlorine and
 - (3) For oil-vapors.

IV. LIME

is used in the old lute known as putty, which consists of caustic lime and linseed oil. Frequently the lime is replaced by chalk and china clay, but the lime should be, in part at least, caustic, so as to form a certain amount of lime soap. Lime is also used in silicate and casein compositions, which are very strong and useful, but will be described elsewhere.

Formulæ : (1) Lime and boiled oil to stiff mass.

- (2) Clay, etc., " " " "

V. ASPHALT AND PITCH.

These substances are used in lutes somewhat interchangeably. As a rule, pitch makes the stronger lutes. Tar is sometimes used, but, because of the light oils and, frequently, water contained, it is not as good as either of the others.

Asphalt dissolved in benzol is very useful for uniting glass for photographic, microscopical and other uses. Also for coating wood, concrete, etc., where the melted asphalt would be too thick to cover well. Benzol is the cheapest solvent that is satisfactory for this purpose, as the only one that is cheaper would be a petroleum naphtha, and it does not dissolve all the constituents of the asphalt. For water-proofing wood, brick, concrete, etc., melted asphalt alone is much used, but when a little paraffin is added it improves its water-proofing qualities, and in particular cases boiled oil is also added to advantage.

Formulæ: (1) Refined lake asphalt.

(2) Asphalt	4 parts.
Paraffin	1 part.
(3) Asphalt	10 parts.
Paraffin	2 "
Boiled oil	1 part.

Any of these may be thinned with hot benzol or toluol. Toluol is less volatile than benzol and about as cheap, if not cheaper, the straw-colored grades being about 24 cents per gallon.

Examples of so-called "Stone Cement" are:

(4) Pitch	8 parts.
Resin	6 "
Wax	1 part.
Plaster	$\frac{1}{4}$ to $\frac{1}{2}$ part.
(5) Pitch	8 parts.
Resin	7 "
Sulphur	2 "
Stone powder	1 part.

These compositions are used to unite slate slabs and stone-ware for domestic, engineering and chemical purposes. Various resin and pitch mixtures are used for these purposes and the proportions of these two ingredients are determined

by the consistency desired. Sulphur and stone powder are added to prevent the formation of cracks. Sulphur acting chemically and stone powder mechanically. Where the lute would come in contact with acid or vapors of the same, limestone should not be the powder used, otherwise it is about the best. Wax is a useful ingredient to keep the composition from getting brittle with age.

A class of lutes under this general grouping that are much used are so-called "Marine Glues." They must be tough and elastic. When used for caulking on a vessel they must expand and contract with the temperature and not crack or come loose.

Formulae :	(6)	Pitch	3 parts.
		Shellac	2 "
		Pure crude rubber	1 part.
	(7)	Pitch	1 "
		Shellac	1 "
		Rubber substitute	1 "

These are used by melting over a burner.

VI. RESIN, SHELLAC AND WAX.

A strong cement used as a stone cement is :

(1)	Resin	8 parts.
	Wax	1 part.
	Turpentine	1 "

It has little or no body and is used in thin layers.

For nitric and hydrochlorine acid vapors :

(2)	Resin	1 part.
	Sulphur	1 "
	Fire clay	2 parts.

Sulphur gives great hardness and permanency to resin lutes, but this composition is somewhat brittle.

Good water-proof lutes of this class are :

(3)	Resin	1 part.
	Wax	1 "
	Powdered stone	2 parts.
(4)	Shellac	5 "
	Wax	1 part.
	Turpentine	1 "
	Chalk, etc.	8 to 10 parts.

For a soft air-tight paste for *ground-glass surfaces* :

- (5) Wax 1 part.
Vaseline 1 "

(6) A strong cement, without body, for *metals* (other than copper or alloys of same), *porcelain* and *glass* is made by letting 1 part of finely powdered shellac stand with 10 parts of ammonia water until solution is effected.

VII. RUBBER.

Because of its toughness, elasticity and resistance to alterative influences, rubber is a very useful constituent in lutes, but its price makes its use very limited.

Leather cement :

- (1) Asphalt 1 part.
Resin 1 "
Gutta percha 4 parts.
Carbon disulphide 20 "

To stand acid vapors :

- (2) Rubber 1 part.
Linseed oil 2 parts.
Fire clay 3 "

Cement for mending rubber :

- (3) Rubber crude (sliced) 1 part.
Resin $\frac{1}{2}$ "
. 8 parts.

(4) *Plain Rubber Cement*.—Cut the crude rubber in small pieces and then add the solvent. Carbon di-sulphide is the best, benzol good and much cheaper, but gasoline is probably most extensively used because of its cheapness.

(5) To make corks and wood impervious to steam and water, soak them in a rubber solution as above; if it is desired to protect them from oil vapors, use glue composition. (See Section IX.)

VIII. LINSEED OIL.

This is one of the most generally useful substances we have for luting purposes, if absorbed by a porous substance that is inert.

- Formulæ : (1) China clay } of general utility for aqueous vapors.
 Linseed oil }
 (2) Lime } forming the well-known putty.
 Linseed oil }
 (3) Red or white lead and linseed oil.

These mixtures become very strong when set and are best diluted with powdered glass, clay or graphite. There are almost an endless number of lutes using metallic oxides and linseed oil. A very good one, not getting as hard as those containing lead, is :

- (4) Oxide of iron and linseed oil.

IX. CASEIN, ALBUMEN AND GLUE.

These if properly made become very tough and tenacious; they stand moderate heat and oil vapors, but not acid vapors.

- (1) Finely powdered casein 12 parts.
 Slaked lime (fresh) 50 "
 Fine sand 50 "
 Water to thick mush.

A very strong cement for ground unions, stands moderate heat, as follows :

- (2) Casein in very fine powder 1 parts.
 Rubbed up with silicate of soda 3 "

A strong lute for general purposes, which must be used promptly when made :

- (3) White of egg made into a paste with slaked lime.

A composition for soaking corks, wood, packing, etc., to render them impervious to oil vapors, is :

- Gelatin or good glue 2 parts.
 Glycerin $\frac{1}{2}$ to 1 part.
 Water 6 parts.
 Oil of wintergreen, etc., to keep from spoiling.

X. SILICATE AND OXY-CHLORIDE CEMENTS.

For oil vapors, standing the highest heat :

- (1) A stiff paste of silicate of soda and asbestos.

Gaskets for super-heated steam, retorts, furnaces, etc. :

- (2) Silicate of soda and powdered glass, dry the mixture and heat.

Not as strong, however, as the following:

- | | |
|--------------------------------|-----------|
| (3) Silicate of soda | 50 parts. |
| Asbestos | 15 " |
| Slaked lime | 10 " |

Metal cement:

- | | |
|---|---------|
| (4) Silicate of soda | 1 part. |
| Oxides of metal, such as zinc oxide; litharge, iron oxide,
singly or mixed | 1 " |

Very hard and extra strong compositions:

- | | |
|-------------------------------|----------|
| (5) Zinc oxide | 2 parts. |
| Zinc chloride | 1 part. |
| Water to make a paste. | |
| (6) Magnesium oxide | 2 parts. |
| Magnesium chloride | 1 part. |
| Water to make a paste. | |

XI. FLOUR AND STARCH COMPOSITIONS.

(1) The well-known flaxseed poultice sets very tough, but does not stand water or condensed steam.

(2) Flour and molasses, made by making a stiff composition of the two. This is an excellent lute to have at hand at all times for emergency use, etc.

(3) Stiff paste of flour and strong zinc chloride solution forms a more impervious lute, and is more permanent as a cement. This is good for most purposes, at ordinary temperature, where it would not be in contact with nitric acid vapors or condensing steam.

(4) A mixture of dextrin and fine sand makes a good composition, mainly used as core compound.

XII. MISCELLANEOUS.

- (1) Litharge.
Glycerin.

Mixed to form a stiff paste, sets and becomes very hard and strong, and is very useful for inserting glass tubes, etc., in iron or brass.

For a high heat:

- | | |
|-----------------------|----------|
| (2) Alumina | 1 part. |
| Sand | 4 parts. |
| Slaked lime | 1 part. |
| Borax | ½ " |
| Water sufficient. | |

Of course, there are an almost infinite number of lutes or cements, but, classified as these are, they represent the largest number of them. The formulas that are not original, or were kindly given by friends, have been seen in the literature one here and one there, and laid aside for a year or more, so I can hardly give the credit for them that I would like to.

A class of mixtures that can only be classified according to their intended use are core compounds.

- (1) Dextrin, about 1 part
 Sand, about 10 parts
 With enough water to form a paste.
- (2) Powdered anthracite coal, with enough molasses to form a stiff paste.
- (3) Resin, partly saponified by soda lye 1 part
 Flour 2 parts
 Sand (with sufficient water) 4 "

(These proportions are approximate and the amount of sand can be increased for some purposes.)

- (4) Glue, powdered 1 part
 Flour 4 parts
 Sand 6 " (with sufficient water).

For some purposes, the exact uses of which I am not familiar, the following mixture is used. It does not seem to be a gasket or a core compound :

- (5) Oats (or wheat) ground 25 parts
 Glue, powdered 6 "
 Sal ammoniac 1 "

I would say in conclusion that in any works or laboratory it is very good to have some such compositions made up ready to use without delay when wanted. Just which one, depends on the nature of the manufacturing or other work done.

I hope that some of the material contained in this paper may prove of benefit to some here present.

IDEAL FUEL OF THE UNITED STATES.

Had Zoroaster pondered the problems of existence on the northwestern flank of the Appalachian Mountains instead of along the shores of the Caspian Sea, he would probably not have lacked the inspiration which gave to his philosophy a symbol of the eternal, for the everlasting fires of the Parsees might be more than duplicated by the springs of natural gas in the United States. Indeed, there is no country in the world which can compare with ours in its production of this perfect fuel. The combined production of all other countries is not over $1\frac{1}{2}$ per cent. of the quantity produced in the United States, which had in 1902 a value of \$30,867,668. A large portion of even the small outside production comes indeed from our neighbor, Canada.

Mr. F. H. Oliphant's report on the "Production of Natural Gas in 1902," which the United States Geological Survey has just published as an extract from its annual volume of "Mineral Resources," is full of interesting details about the history, output, value and uses of this most satisfactory combustible.

The records of early investigators and missionaries show that natural gas has been known to exist in natural springs in western New York, western Pennsylvania, central West Virginia, northeastern Kentucky and southeastern Ohio for at least 250 years. In 1775 General Washington visited a burning natural gas spring on the northeast bank of the Great Kanawha River in West Virginia, a few miles east of the present city of Charleston. He was so impressed by the phenomenon that he pre-empted an acre of land surrounding the spring and dedicated it to the public forever.

The earliest economic use of natural gas in this country was probably made in lighting the village of Fredonia, Chautauqua County, New York, in 1821. The existence and utilization of this gas at Fredonia became widely known, both in this country and abroad, and excited the liveliest interest among scientific men. So little suspected, however, was the presence of the enormous volume of gas since developed that, when it was further explored, it was pronounced "unparalleled on the face of the globe," and Humboldt is quoted as declaring it the eighth wonder of the world.

Its introduction into commercial use was slow, but after its value was fully demonstrated there was a rush of capital, and a large amount of money was invested in gas territory, gas wells, and pipe lines. Then followed a period of reckless consumption and appalling waste. Many of the original fields were rapidly depleted of their high pressure. Not until it was fully realized that a large proportion of the natural supply had been consumed and dissipated by the extravagant methods in use were improved means adopted for holding back the gas in the original rock reservoirs. This was done by shutting off the wells, by cutting off all blow-off standpipes and escapes, by improving the joints of the pipe lines, and by the more economical consumption of the gas.

This economy came rather late, but enough of the original supply remains, stored principally in the deep and prolific sands of northern and southwestern Pennsylvania and western West Virginia, to furnish this ideal household fuel for many years to come. What may be done by deeper drilling and improved methods to prolong its use indefinitely is yet unknown.

CHEMICAL SECTION.

*Stated Meeting, held Thursday, January 28, 1904.*Early Chemical Manufactures.—A Contribution to the
History of the Rise and Development of Chemical
Industries in America.

BY M. I. WILBERT,
Member of the Institute.

Chemical industries play such an important part in supplying the needs and wants of our every-day life that we, at times, can hardly realize that the time was, and not so long ago, when in the whole length and breadth of this great land there were practically no manufactures of this kind. It is now not much more than a century ago since the manufacture of chemicals, as such, was commenced in this city, and this, so far as known, was the first in the country. In a short sketch of this kind, it would, of course, be practically impossible to describe, or even enumerate, all of the concerns that have been interested in the manufacture of chemicals since the first introduction of the industry in America. We will content ourselves, therefore, by attempting to call your attention to some of the varied and interesting materials that are available for an extended sketch, or a history, of this subject.

Chemical processes enter so largely into manufactures of all kinds that it is at times difficult indeed to draw a distinctive line between what may or may not properly be classed as chemical products. For this reason we will confine ourselves, as much as possible, to the enumeration of substances of a distinctly chemical nature that are or may be used in other arts and manufactures or in the practice of medicine.

There is no distinct evidence that the aboriginal inhabitants of any portion of North America produced or used chemical substances as such. A number of these inhabit-

ants did make use of chemical processes in the making or manufacture of pottery, paper, paint pigments and fermented drinks; but even these were produced in limited quantities, and there was nothing like a general or widespread industry.

Chronologically, then, the earlier efforts at the manufacture of chemical substances may readily be divided into three distinct periods.

(1) The colonial period, from the first settlement of the country, to the time of the revolutionary war.

(2) The period from the revolutionary war to the war of 1812.

(3) The period from the war of 1812 to the rejuvenation of interest in scientific pursuits, about the middle of the nineteenth century.

The chemical manufactures of these several periods were quite distinctive. In the first period the manufactures, in the chemical line, were confined to the production of potashes and lime, with stray experiments and trials in the manufacture of salt, saltpeter and gunpowder.

In the second period, largely, if not entirely, brought about by the exigencies of war, manufactures of salt and gunpowder were established as permanent industries, while the manufacture of paint pigments and a number of chemical substances was tentatively established in Philadelphia.

In the third period, due directly to the war of 1812 and the commercial restrictions which preceded it, we have the introduction of the manufacture of sundry chemicals for technical and medicinal purposes.

So far as is known, the first chemical substances made in America were produced in the Jamestown Colony, where as early as 1608 the manufacture of pot- or soapashes was tried, and the resulting product, with samples of pitch, glass and clapboards, was sent to England by these first colonists.

It would appear, therefore, that chemical substances were among the first exports of manufactured articles from what is now the United States.

While there is little or no evidence that the manufacture of potashes was entered into extensively for the next two or

three decades, pot- and pearlashes did, in later periods, constitute a very important article in the exports of nearly all of the English Colonies in North America.

In this connection it might be of interest to mention that there are a number of records of premiums having been offered and awarded, by both home and colonial societies, for the encouragement of the industrial arts, for the largest and best production of pot- or pearlashes.

Gabriel Thomas, in his account of Philadelphia and the province to the year 1696, mentions potashes among the list of exports, and in later years, even down to the opening decades of the nineteenth century, the making of potashes constituted one of the more important industries of Philadelphia, a number of manufacturers of this product being located along the Delaware front.

During the colonial period potash works were numerous throughout the American colonies. In Massachusetts alone, toward the end of the eighteenth century, it was estimated that they numbered fully 250. Many of these establishments were being conducted on a large scale and were quite successful. The average exports of pot- and pearlashes from the United States at the beginning of the nineteenth century, according to the "Statistical Annals of the United States from 1789 to 1818," by Adam Seybert, was about 6,000 tons annually.

The manufacture of soap was probably one of the first uses for which the alkali was employed in the colonies. Soap boiling as a commercial venture was introduced at quite an early date. The father of Benjamin Franklin, Josiah Franklin, was probably one of the first to engage in it as a business. Josiah Franklin, a dyer by trade, came to Massachusetts about 1682 and engaged in business as a tallow-chandler and soapboiler.

The earliest mention of the manufacture of lime is probably that in the records of Providence, Rhode Island, where, in 1662, a Mr. Hatchet applied for liberty to burn lime and to take stone and wood from the public commons for the purpose.

It is quite probable, however, that lime had been burned,

even before this date, from shells that were found in great profusion along the coast. This shell lime was the principal dependence in several of the colonies until after the beginning of the eighteenth century.

In or near Philadelphia, lime is said to have been made from limestone, about 1681, at Mountjoy, a manor that belonged to Letitia, the daughter of William Penn.

Common salt, one of the prime necessities of the European, was first made in the Virginia Colony some time previous to 1620. These earlier works were allowed to fall into decay, but were rebuilt, and in 1633 there is a record of salt having been made in appreciable quantity. In that year a considerable amount of salt was exported to Massachusetts for use in the fisheries.

About 1623 salt works were erected by a company on a site in or near the present city of Portsmouth, N. H. Several other attempts at the manufacture of salt from sea water are recorded, but as none of these proved successful or were continued for any length of time, it will not be necessary to enumerate them further.

It was not until the time of the Revolution that the manufacture of salt was established as a permanent industry.

The salt springs of Central New York were first discovered about 1654 by Père Le Moyne, a French Jesuit. They were not readily accessible, however, and were not developed in a commercial way until some time after the American Revolution, or nearly 150 years after their discovery.

The interruption of foreign trade by the Revolutionary War led to the organization of a great number of small establishments for the manufacture of salt all along the Atlantic seaboard from Cape Cod to Georgia.

One of the more successful of these early salt manufactories was established on Quivet Neck, in the town of Dennis, Barnstable County, Mass., by John Sears, a mariner. This pioneer salt maker had probably become acquainted with the salt works along the Mediterranean or in the West India Islands and conceived the idea of making salt by the use of solar heat exclusively. This establishment, dubbed

by the natives "John Sears' folly," was the first of a number of works in Barnstable County, where the salt industry subsequently developed into a large and flourishing business, in the early decades of the nineteenth century.

During the Revolution common salt was the most prized of all commodities. The ordinary product that before the war sold for 2 shillings a bushel rapidly increased in price, and in 1776 was not to be had for 25 shillings a bushel.

Philadelphia, with the surrounding country, was severely affected by this scarcity, and increase in the price, of salt, and several attempts were made to establish salt works along the New Jersey coast. One of these, at Tom's River, was conducted for a time by Thomas Savage, and was, with a number of others, burned or demolished by the British troops during the war.

For some time after the Revolution, salt in the country west of the Allegheny Mountains was worth "a cow and a calf" a bushel. This was the prevailing price until some time after 1790, when salt from the Onondaga salines was introduced and this, for a number of years, supplied a large portion of the western country. As late as 1815 salt in Cincinnati was quoted at from \$3 to \$5 a bushel, while the earlier settlers were obliged to pay as much as \$7 and \$8 for a very inferior quality. Salt was made on the Wabash, in the Indiana Territory, early in the nineteenth century.

The manufacture of salt was also commenced in Western Pennsylvania about 1812 and this led to the establishment of a number of similar works in Southern Ohio and also in what is now West Virginia.

Another substance of a chemical nature that was absolutely essential to the colonists was gunpowder. The manufacture of this product was attempted at an early date, the first available record being in 1639, when Edward Rawson was granted 500 acres of land at Pecoit, Mass., to aid him in developing the manufacture of this very essential article.

In 1642, to promote and perfect the making of gunpowder, it was directed that every plantation within the Colony of Massachusetts should erect a suitable house to make salt-

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peter. There are several additional records of early powder mills in Massachusetts, as well as in other Colonies, but none of them appear to have been continued for any length of time.

The exportation of powder and its materials from England was prohibited by an order in Council, of October 19, 1774, so that the American Colonies were made dependent on other sources for their supply.

The Continental Congress, in various ways, encouraged the erection of powder mills, and also the production of nitrate of potash. Congress, in 1775, published a manual giving directions for making saltpeter, and about the same time the "Committee of the City and Liberties" erected a large saltpeter works on Market Street for the double purpose of making saltpeter and also to instruct such as were willing to engage in the making of this very necessary article for the powder mills.

Similar works were also erected in Boston by Dr. Whitaker and by others in different places.

As a further source of supply the ground about the tobacco warehouses in Virginia and Maryland was dug up and leached out and considerable quantities of potassium nitrate were obtained in this way.

In this same connection it may be interesting to note that, during the war of 1812, a very large amount of saltpeter was obtained by leaching out the deposits in the limestone caves of Kentucky.

The manufacture of gunpowder was very extensively carried on during the Revolution in nearly all of the American Colonies. A very large proportion of this powder, however, was made in Pennsylvania. Philadelphia was among the first places in which powder mills were successfully operated.

Early in the Revolution a public powder mill was established in or near Philadelphia by the Assembly, while Congress opened, and for some time operated, what was known as "The Continental Powder Mill." Congress also offered advances to such persons as would be willing to establish powder mills within fifty miles of the city of Phil-

adelphia, and this offer was taken advantage of by many who subsequently supplied a liberal proportion of the powder used in the Continental Army.

Probably the oldest of the still existing powder mills was established about 1802 by Eleuthere Irene Du Pont, who came to this country from France in 1799. Du Pont established his first mill on the Brandywine, about four miles above what was then the village of Wilmington. Having had some experience in the manufacture of gunpowder in France and being able to produce a quality much superior to that in use in this country at that time, he soon established a business that developed into the most extensive of the kind in the country.

Philadelphia and Philadelphians have taken a very important part in the origin and development of chemical industries of all kinds. Probably the first to inaugurate the manufacture of chemicals, as such, in this country, was the firm of Christopher, Jr., and Charles Marshall, sons and successors of Christopher Marshall, an early druggist and one of the original "fighting Quakers" of Philadelphia, this firm had, as early as 1786, entered quite extensively into the business of making muriate of ammonia and Glauber's salt. The factory is described by Watson, in his "Annals of Philadelphia," as being a grim and forbidding-looking building on Third Street near the stone bridge over the Cohocksink Creek. This firm is said to have developed an annual output of upwards of 6,000 pounds of muriate of ammonia; quite an achievement for that time.

The manufacture of white lead was commenced by Samuel Wetherill, another Philadelphia druggist, about 1789. This business rapidly developed, despite the reputed opposition of English manufacturers. In 1809 extensive works were opened at or near the corner of Broad and Chestnut Streets. These being destroyed by fire a new plant was erected at the corner of Twelfth and Cherry Streets. This for a number of years was the site of the now very extensive manufacture of white lead and color pigments. After the enforcement of the Embargo Act, which preceded the war of 1812, a number of manufacturers en-

gaged in the manufacture of white lead and paint. Among these was Dr. Joseph Strong, who undertook the manufacture of various lead pigments at his laboratory, 485 North Third Street, opposite the Globe Mills. Joseph Richards, about 1812, established a factory on Race Street near the Schuylkill River. This was later removed to Pine Street above Broad, where he was succeeded by the two brothers, Mordecai and Samuel N. Lewis, who developed a large and lucrative business. Harrison Brothers were also among the first to engage in the manufacture of white lead. The founder of this firm, John Harrison, was probably the first to manufacture sulphuric acid in the United States.

Sulphuric acid has been, quite properly, called the basis of all chemical industries. It is for this reason that the credit for establishing chemical industries in the United States is frequently accorded to John Harrison, a Philadelphia druggist, who, about 1793, was the first to produce sulphuric acid in a commercial way.

Mr. Harrison sold out his drug business in 1806 and devoted himself exclusively to the manufacture of acids and chemicals. It was not long before others followed in the manufacture of the heavy acids. In Philadelphia, Farr & Kunzi were probably the first to follow the example of Mr. Harrison. They engaged in the manufacture of sulphuric acid about 1812, and were soon followed by Wetherill & Brothers, who opened a manufactory of oil of vitriol on the east bank of the Schuylkill River. Mr. Harrison was also the first in this country to have and to use a platinum still. This still was constructed by a Dane, Erick Bollman, who appears to have been a man of more than ordinary attainments and who was particularly well versed in metallurgy.

Charles Lennig is said to have been the first to enter into the manufacture of sulphuric acid on a large scale, and he was also the first to use platinum stills so arranged that the operation was practically continuous and automatic.

Charles Lennig was the founder of the well-known firm of Nicholas, now Charles, Lennig & Co. He began operations about 1831, and in addition to the heavy acids made a number of chemicals for the use of textile manufacturers and dyers.

The development of the textile industry in different sections of the New England States created considerable demand for a number of chemical substances, particularly sulphuric and muriatic acids and the salts commonly used in bleaching and dyeing. This demand brought about the establishment of chemical manufactures in the same locality. The plants at Roxbury and Salem, Mass., were probably among the first to be established in New England.

The first to manufacture acids and heavy chemicals west of the Allegheny Mountains was Eugene Graselli, who built a large laboratory and established a successful business some time between 1820 and 1850. He was followed some years later by Harwood & Marsh, also in Cincinnati. Other manufacturers followed, and about the year 1850 sulphuric acid was being made in Pittsburg, Pa.; Steubenville, O.; St. Louis, Mo.; New Orleans, La., and probably in other towns and cities west of the Allegheny Mountains.

The commercial restrictions that preceded the war of 1812 were the direct cause of firmly establishing a number of chemical manufactures as permanent industries.

Among the chemicals, the manufacture of which was introduced about this time, is copperas. This was first made at Strafford, Vt., about 1810, from native pyrites. Copperas was also made at a very early date at Pequannock, Morris County, N. J., and about the year 1811 works were opened on the Magothy River, Md., by Richard Colton and others. About three years later the manufacture of alum was added and the works were then put in charge of Gerard Troost, a Hollander by birth, who, though undoubtedly a poor business man, was a scientist of exceptional attainments and abilities. Gerard Troost was one of the founders of the Academy of Natural Sciences of this city. He was an able geologist, an excellent chemist and an efficient teacher. He was, about 1823, professor of chemistry at the Philadelphia College of Pharmacy. Later, he was for some years one of the professors in the University of Nashville and also served as geologist to the State of Tennessee.

Epsom salt is said to have been made in this country as early as 1790 in the town of Bridport, Addison County,

Vermont, from the waters of a mineral spring discovered by the Rev. Sylvanus Chapin. The same substance was also made at quite an early date in or near Baltimore, Md., from native magnesite, while in Barnstable County, Mass., Epsom and Glauber's salt were early obtained as by-products in the manufacture of salt.

In the first copy of the *American Journal of Pharmacy*, then called the *Journal of the Philadelphia College of Pharmacy*, published in 1825, Daniel B. Smith describes at some length the details of the manufacture of Epsom salt in Barnstable County, Mass. The credit for developing this particular portion of the industry is said to be due to the Rev. Mr. Briggs, who is described as being an industrious and ingenious chemist.

The Epsom salt of that early day was quite different in appearance, and also in price, from what we would expect at present. It was usually wet and soggy, always impure and, not infrequently, mixed with, or sometimes substituted by, Glauber's salt. The difference in the price, in the early decades of the last century, made this quite a profitable form of adulteration. Epsom salt selling regularly for fifteen cents a pound, while Glauber's salt could be had for from two and a half to three cents a pound.

Chromates were probably first made in Baltimore, though as early as 1816 a Mr. Wesener, a German chemist, had established himself in Philadelphia, in the neighborhood of Broad and Cherry Streets, where he made chrome salts and chrome pigments in considerable quantities. Being nearer the source of supply of the raw material, the Baltimore manufacturers had a decided advantage, so much so that before the middle of the last century the business had drifted back to that city.

Among the earlier manufacturers of chrome salts in Baltimore were Isaac Tyson & Son and William Davidson & Co. This latter firm also made ferrocyanide salts and probably other heavy chemicals.

The manufacture of ferrocyanides was also carried on quite extensively in Philadelphia, and it may be interesting to note, in this connection, that it was in the manufacture

of ferrocyanide of potash that the first attempts were made to utilize atmospheric nitrogen by combining it with carbon at very high temperatures. The manufacture of ferrocyanides was, at a later period, gone into quite extensively at Cincinnati, Ohio, where the large pork-packing establishments insured an ample and cheap supply of organic materials necessary in its manufacture. About 1850, one firm alone in Cincinnati produced annually upwards of 60,000 pounds of prussiate of potash.

The manufacture of bromine, as a by-product in the production of salt, was commenced at the salt springs near Pittsburg about 1845, and soon assumed enormous proportions.

Soda salts, particularly soda ash, sodium carbonate and also sodium bicarbonate (the latter first known as soda salæratum and later as baking soda), have developed into an enormous and highly specialized branch of chemical manufactures.

Among the first in this country to manufacture soda ash on a large scale was the Pennsylvania Salt Company, at Tarentum, near Pittsburg. This company, although it has probably developed along different lines from what was at first anticipated, has amply verified a prophecy, made more than fifty years ago, that it would become one of the largest chemical works in the Union.

John Dwight and Austin Church began the manufacture of soda salæratum about 1846. They were eminently successful and practically controlled the American market for sodium bicarbonate for a number of years. The rapid development in the manufacture of this particular product is well illustrated by a comparison of prices. In 1820, what was then called supercarbonate of soda, was listed and sold regularly for \$1.25 per pound, while in 1850 the same amount could be had, in regular trade, for 4 cents.

Previous to 1850, and for some time after that, Philadelphia was the acknowledged center for the manufacture of chemicals for medicinal use. One of the first to engage in this branch of chemical manufactures was Dr. Adam Seybert, a graduate of the Medical Department of the University

of Pennsylvania, class of 1793. He was also one of the more prominent members of the Philadelphia Chemical Society. This society, as is well known, took an active part in the development of the mineral resources of the United States.

In 1801, Dr. Seybert established a chemical laboratory at No. 168 North Second Street, where he is said to have made the first mercurials made in this country.

The first to follow him in this line was John Shinn, Jr., who, about 1810, established a laboratory at No. 282 North Third Street for the manufacture of calomel, corrosive sublimate and a number of other chemicals for medicinal and technical uses.

About this same time (1810) Innes & Robertson established a laboratory in Elizabethtown, New Jersey, where they made aqua ammoniæ, sulphuric ether, benzoic acid, and, some time later, added a full line of mercurials and other medicinal chemicals.

About 1811, Dr. Gerard Troost, who has been mentioned before in this sketch, in company with his brother, Benoit Troost, began the manufacture of a variety of chemicals for medicinal use in a laboratory on Coates Street (now Fairmount Avenue), in this city.

The Wetherills were also manufacturers of a line of chemicals in their extensive laboratory at the corner of Twelfth and Cherry Streets.

Farr & Kunzi began the manufacture of chemicals about 1818. Abraham Kunzi, a Swiss by birth, retired in 1838, and the senior partner, John Farr, who had been born and brought up in England, associated with himself Thomas H. Powers and William Weightman, two young Philadelphians, who had been in the employ of the firm for some time. The new firm name was John Farr & Co. This was later changed to Farr, Powers & Weightman, and, on the death of the senior partner in 1841, the firm name was again changed; this time to the still existing title—Powers & Weightman. This firm, for a number of years, was considered to be one of the largest general chemical manufacturing concerns in the United States, and it still holds an enviable reputation for the quality and reliability of its manufactures.

George D. Rosengarten and Charles Zeitler, as Rosengarten & Zeitler, began the manufacture of chemicals in St. John Street, Philadelphia, about 1822. They were among the first to manufacture the alkaloids of cinchona and opium in this country. Zeitler, while admittedly a very able chemist, appears to have been rather eccentric in his ways. He withdrew from the firm about a year later and Mr. Rosengarten continued the business alone until 1834, when he associated with him N. F. Dennis, a French chemist of considerable ability. The firm continued as Rosengarten & Dennis until 1855, when the junior partner withdrew and the firm name was changed to its present style, Rosengarten & Sons, the laboratory, about the same time, being removed to its present location at Seventeenth and Fitzwater Streets. There were, of course, a number of other manufacturers of medicinal chemicals, but the majority of them have long since specialized into one or two particular lines or have discontinued business. One of the latter, Charles Ellis & Co., were at one time extensive manufacturers of chemicals. They were the successors of Christopher Marshall, who, in turn, was probably the first druggist, with any appreciable amount of chemical training, to settle in America.

Any historic account of the development of the chemical industries in America would be incomplete without at least some reference to the rise and development of the teaching of the technical side of chemistry.

The first systematic attempt to teach the principles of chemistry was made in 1765 in connection with the medical department of the, then, College of Philadelphia. The first teacher of this branch of science was John Morgan, the founder of the Medical School.

No separate chair of chemistry was instituted until 1769, when Benjamin Rush was appointed professor of chemistry in the same school.

The first school to institute a chair of chemistry as part of a collegiate education was the College of New Jersey, now Princeton, where John MacLean taught chemistry some years before the beginning of the nineteenth century.

Popular lectures on chemical subjects were given in

Philadelphia as early as 1807, when Dr. Joseph Parrish, then quite a young man, commenced a series of public lectures on chemical subjects. To Dr. Parrish must be given the credit of establishing a system of instruction, by means of popular scientific lectures, that has done much to keep the citizens of Philadelphia in touch with modern progress.

Probably the first institution to take up and elaborate on this idea of popular instruction was the Franklin Institute. This institute, from its foundation, has always adhered to the practice of giving popular scientific lectures. The first course of these lectures was given in the old Academy Building, the original home of the College of Philadelphia, and later in Carpenters' Hall, where, also, was held the first exhibition ever given under the auspices of the Institute. On the completion of its own building the lectures were given in its own, now venerable, hall.

Altogether, the Franklin Institute has contributed no unimportant part to the progress of chemical industries in the United States. The popular lectures on chemistry no doubt tended to awaken a lively interest in the subject, while the, at first, annual, and later, periodical exhibitions, in connection with the reports and other papers published in the *Journal* of the Institute, have served to collect and give information of great value to the pioneer manufacturer.

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Section of Photography and Microscopy.

Stated Meeting, held Thursday, October 29, 1903.

Improved Methods of Producing Color Values for Monochrome and Three-Color Printing.

BY JOHN CARBUTT,
Member of the Institute.

In bringing to the notice of the members of the Franklin Institute improved methods of producing color values for monochrome and three-color printing we will first briefly trace the origin and growth of what is now recognized, from the scientific and commercial standpoints, as one of the most wonderful achievements in photography.

In 1861 James Clerk-Maxwell first experimented with three-color photography, and the color curves plotted by him are the base on which the results of to-day are obtained. But at that date there were no color sensitive plates to be had, and the subject lay in abeyance until the late Dr. Herman Vogel, of Berlin, in 1873 found by the addition of certain dyes to collodion (principally of the eosine group) a better rendering of the greens and yellows was obtained. Captain Waterhouse also experimented on the same lines. In 1878-9 Mr. F. E. Ives produced very red sensitive collodion plates by the use of chlorophyll as a sensitizer. The late Mr. Carey Lea also made extensive experiments with salts of chlorine to produce color values, but, owing to the slowness of collodion and the long exposure required to reproduce the red, the securing of color values by photography was only made possible on the advent of the more sensitive gelatine dry plates. In 1883 Tailfer and Clayton, of Paris, brought out a dry gelatine plate color sensitized with eosine, and the same was introduced commercially in London in 1884 by Mr. J. B. Edwards. Learning of this through the *British Photographic Journals*, I took up the study of the subject, and in 1885 commenced the manufacture of orthochromatic plates. These plates,

with the aid of a yellow screen for landscapes, flowers, etc., and an orange screen for copying paintings, produce satisfactory color values, including blue, green, yellow and orange, but lack the power to reproduce red, unless a very dark red filter is used, entailing a very protracted exposure.

It is a little over two years since I commenced experimenting to produce a color-sensitive plate that would be sensitive normally to all colors of the spectrum. I found little difficulty in preparing a plate well sensitive to orange and red, but the spectrum test showed lack of sensitiveness to the blue green, and it took a great many experiments and combinations of dyes to overcome lack of sensitiveness in the line "F" of the spectrum, and which I finally achieved, as will be shown on the screen later. This plate I named "Polychromatic," as it is sensitive to all colors of the spectrum—from blue to red. Then came the necessity of suitable light filters to use with the polychromatic plate, so as to produce the Clerk-Maxwell color curve on the three respective negatives, from which three positives—either by contact with a medium rapid dry plate or in the camera, and the final negatives taken through the ruled line screens of Levy's (usually by the wet collodion process)—are made. And from these negatives the three half-tone copper-plates are produced. Now while the Clerk-Maxwell method is quite correct in theory, the practical three-color workers find it too exacting to produce printing plates requiring little or no re-etching; consequently they (the etchers) prefer a more distinct separating of the color values than an over-lapping curve, as will be seen in the spectrum image taken through three-color filters on the polychromatic plate. To meet this requirement I am making color-sensitive plates in two series, "C" and "D." The C plate is strongly red sensitive with green subdued, while the D plate is strongly green sensitive with red, orange and yellow subdued. The advantage is that a much lighter red filter can be used with the C plate to secure the red for blue printing plate, and a lighter green with the D plate for the red printing plate, and time of exposure reduced with both, while the C plate can be used with the violet blue filter

for yellow printing plate, and as some three-color printers prefer a trace of red in the yellow plate, the C plate and a violet-blue filter accomplish this. Besides the method here outlined, which requires the use of nine plates, a more direct method is now being practised, both in Europe and America, both with collodion and gelatine plates, by what is called "the direct method;" that is, the exposure is made through the light filters and the ruled screen, producing at one operation, when carefully carried out, the results obtained with three original negatives, then three positives and the final wet-plate negative through the ruled screen.

Three-color photography is now of wide application, both in the reproduction of works of art and manufactured articles. American three color printers are in no way behind in their productions in comparison with foreign three-color printers. Philadelphia has several such establishments. A few examples of their work I have brought for your inspection.

I would call you attention to the series of prints representing the stages of three-color printing by which the final delicate and beautiful results are obtained. First print in yellow ink, next in red, then in blue, showing the shades of ink used. Then the red is printed over yellow, and finally the blue. The change, making the complete print, seems almost magical.*

Correspondence.

CONTROLLING THE FLOODS OF THE MISSISSIPPI.

To the Committee on Publications.

GENTLEMEN:—The October number of the *Journal* of your Institute contained an article by Prof. Lewis M. Haupt about "Controlling the Floods of the Mississippi River," which was of special interest to me. But although the premises of the question are exposed in the clearest manner, I regret to

* Mr. Carbutt closed his remarks by exhibiting on the screen a number of slides to further explain the production of monochrome and negatives for three-color process, and expressed his indebtedness for examples of three-color printing, used in the illustration of his remarks, to the Electro-Tint Engraving Company, and the Photo-Chromotype Engraving Company, of Philadelphia.

declare, with all diffidence, that I cannot agree with the author's conclusions, and that I am convinced that if the policy advocated should be followed, the lower Mississippi will be irretrievably lost as a navigable canal and will be converted into a miserable swamp, where numberless anopheles will propagate malaria in the form of yellow fever, cholera asiatica, etc.; where only alligators and snakes can live and no human being can take up his abode without risk of premature death.

The lower Mississippi has much resemblance with the Netherlands as being the Δ of the great river. So the Netherlands are the Δ of three rivers: the Rhine (Rijn), the Meuse (Maas) and the Scheldt (Schelde). In past centuries the fertile banks created by these rivers were converted into pasture lands, by embanking, enclosing them by dykes, extending the enclosed lands by other dykes, and creating the so-called "polders." Sluices let out the superfluous rain water and protected the land against inundation by floods. But in past centuries there was no strong central power and every peasant "impoldered" his land as he liked, without any regard to his neighbor or to the general welfare.

After Charles the Great the feudal system was introduced, and the petty barons, the landed aristocracy, were put under control of the "Graaf" (Count). The landed proprietor who wanted to protect his land by dykes (levees, as the lower Mississippian, after Creole fashion, would say), asked permission and the Graaf granted him a "handfest" (handfast charter). But centralization did not suit the proud barons of these times; many were the intrusions upon the Kaiser's, or his representatives', regulations; and if the latter tried to enforce the Kaiser's or his own commands, and perhaps was too attentive to the baron's wife or daughters, the baron made short work with him by slaughtering him on a hunting party (as was the case with Flores V, "der Kerlen Gott," viz., the God of the Carls). Then came the stirring times of the thirty years' war, the struggle for liberty of thought, times of heroic action; but not very apt for peaceful centralization of power. Throughout the whole of the seventeenth century there was a struggle between the central power: the "Algemeene Staten" with the "Provinciale Staten" and the wealthy municipal boards. There was no eminent head of the State. The able "Raadpensionaris," Jan de Witt, had no real power; he derived his power from his commanding spirit and his eminent abilities as a statesman, diplomat, navigator and mathematician. The Princes of Oranje were also recognized more or less as Chiefs, and as long as they shone by their talents at the head of the commonwealth, the petty citizens recognized their power more or less; but beyond diplomatic and military business, their power did not reach very far. And besides, the times were still very unsettled by wars with the British nation under the Stuarts and Cromwell, and against Louis XIV.

The house of Oranje-Nassau died out with William III and its interests were transferred to the Friesian branch, whose ancestor, Willem Lodewyk, was the able coadjutor of the "Vader des Vaderlands," Willem de Zwijger, his brother; but brilliant as were the descendants of the latter, as dull were those of Willem Lodewyk, and the once so brilliant house of Oranje sunk into utter insignificance under William IV and unto worse still under his son, William V, who was ignominiously driven from his seat and the country.

Centralization under these circumstances could not make good progress, at least not from above; but from below there rose a spirit of coöperation, which bore good fruit. The polders who had a common waterway for getting rid of their superfluous water, united themselves into a common "Waterschap," with a board of directors chosen by the "Ingelanden" or petty proprietors; the members of the board were called "heemraden." Smaller concerns were united into greater ones under a board of "Hoogheemraden," chosen by the "Hoofdingelanden;" the later chosen by the "Ingelanden." For the executive there was the "Dykgraaf," which title recalls its mediæval origin from the feudal system. The Dykgraaf had his staff of opzichters, fabryks, etc., which we now should call engineers, chief engineers, etc. In this way originated the great Waterschaps or Hoogheemraadschaps of Amstelland, Rynland, Delfland, Schieland, Krimpener-waard, Bommeler-waard, Thielers-waard, etc. (waard-guard, the board to guard the interests of the lands of Krimpen, etc.).

Generally speaking, these boards were admirably organized for guarding the limited interests of their respective Waterschaps, but the country needed a general system of control of the waterways, etc. The consequence was that the rivers above named were badly injured as waterways, as no one took the proper interest in their conservation. The Rhine, the splendid Rhine, smothered near Katwyk in the Downs. Maas and Schelde had an intricate outlet, which was joined by byways from the Rhine. The waterway from Rotterdam, the second port of the country, to sea, became silted up and useless for the India trader. A channel through the Island of Voorne was dug, protected by sluices, and the ships had to pass these sluices and had to be towed from the "Nieuwe Maas" into the "Oude Maas" and to proceed to sea by the "Bokkegatt," but this outlet also became too shallow a waterway. The India trader had to take still another route, the "Brouwerhavensche Gat," by a very dangerous bar, the "Banjaard." This intricate passage from Rotterdam to the sea was even not without its dangers. The Hellegat became silted up and had to be replaced by the "Ventjagersgat." Other difficulties arose from the Δ formation of our great rivers, uncontrolled by man, but aggravated by the uncontrolled action of petty freeholders, of petty towns who wanted their own petty harbors, their own petty waterways, and who sought to improve their own petty interests without regard for the great interests of general public welfare.

After the fall of the Stadhouder system of government, the country came under French influence with its centralizing tendency. In the meanwhile there had risen a remarkable man, Cornelis Rudolphus Theodorus Krayenhof. Bred as a physician, his tastes were for the engineering profession, and in the stirring times of the French revolution he exchanged clyster for compass and took an active part with Marshall Daendels in the defence of Noord-Holland against the invasion of the combined Russians and Englishmen. His part was the regulation of the system of inundations, which proved an impenetrable barrier against the foreign invaders, who were defeated by Daendels at Bergen and Castricum, and had to retire and leave the country. Under King Louis Bonaparte, Krayenhof put Amsterdam in a state of defence and changed it into an impregnable fortress against Napoleon. But Louis, at the last moment, yielded to his brother. Napoleon, who even in his

enemies recognized their merits, was not slow to find them out with Krayenhof, who, under his reign rose to the office of member of the Imperial Committee of Fortifications under the presidency of no less a general than the Emperor himself. After the Emperor's fall, Krayenhof, who had belonged to the anti-Stadhouder's party, although apparently high in honors, was not a favorite at court. William I, a narrow-minded individual, a bad politician, but a good administrator for his own purse, cherished a deep rancor against the old patriot, the "keezendoctor" as he called him; with small intrigues the great man fell as a victim of a miserable cabal, provoked by a sovereign who dared not attack him openly. The old man provoked a legal investigation of his case and was most brilliantly acquitted of every charge which malice had invented, but not long afterwards he died a broken man, burdened by a disgrace from an ignorant, bigot sovereign, the degenerate descendant of one of the most illustrious houses, which traced its descent from Guillaume au Courtnez, one of Charles the Great's paladins.

Krayenhof was a peculiar character; he was a son of his land as well as one of his age. In our country the military man is also more or less a hydrographer or engineer. So, for instance, Krayenhof's great predecessor under William III, the stout baron of Coehoorn, was as eminent an engineer as a tactician and, besides, a technical artilleryist. The same may be said of the late F. J. Stieltjes. As a son of his times, Krayenhof started the centralization of the hydrographic condition of his country. A triangulation of the country was executed, and later triangulations with more refined instruments have proved the high degree of accuracy of his work. The reference level of the "Amsterdamsche peil" was spread over the country, and last, not least, Krayenhof projected a general scheme of regulating, or, as it is called in the Netherlands, the normalizing of its river system. The principles of his scheme were the following: each river should have its own well-defined road-bed, undisturbed by the waters of other rivers; Δ formation should be repelled as much as possible.

Meanwhile a new department of public service was created; that of the "Waterstaat," the central controlling body for all matters in relation to the hydrography of the country. This body became celebrated by the dynasties of the Brunings, the Conrads, the Calands. Of these, W. F. Conrad has been before the world's footlights as President of the International Committee of the Suez Canal. A committee of two eminent engineers of the corps of Waterstaat was nominated to consider Krayenhof's plans and propositions, the Messrs. Ferrand and van der Kun, and to project a general plan for the river system. Their report was in favor of Krayenhof's propositions, and in working out his ideas they decided that each river should have a summer-bed, a winter-bed and an inundation or emergency bed; that the river should have a road-bed regularly extending in capacity from its origin to its mouth; the winter-bed should not be interfered with by dykes, zomerkaden (summer-quays or small dykes), etc.; where the bed is too broad it should be regulated by cribs (groynes), and not by dykes (levees); the curves or bends should be as few as possible and with a radius of curvature as great as possible; the mouth should be as broad as possible. These principles were accepted and their execution regularly proceeded with in time. The Rhine was already irretrievably lost; but an artificial mouth was created by a canal with sluices,

cut through the downs, to secure the Watershap of Rynland ready means of discharging its superfluous water into the North Sea. Under Chief-inspector Caland the plans were worked out, and under his guidance the regulation of the Rhine, by giving it an independent outlet through the mouth of the Nieuwe Maas was started, and afterwards the Maas was regulated and got its independent road-bed and mouth through the Oude Maas and Bokkegat. The Rhine now delivers its waters through the Waal and Nieuwe Maas. Its road-bed is systematically regulated short cuts. "Coupures" as those of the Pley were executed to straighten its course; last, but not least, a new mouth was dug at the Hoek van Holland, and the old mouth was dammed up and closed. Long break-waters or jetties constructed of fascines prolonged the new mouth far into the North Sea. The works were crowned with success. Disastrous floods are now a thing of the past. Rotterdam has a splendid waterway into sea, and the inner navigation has not to stop for lack of water in the summer months. Land reclamation goes regularly on without, as in former times, encumbering the river's road-bed.

And when after this long discursion I return to the Mississippi, I remark that Professor Haupt's proposals, at least some of them, are in direct contradiction with the principles which have guided the Waterstaat engineers in the Netherlands and whose works proved so successful. The Professor's proposal of creating "outlets" will prove disastrous and will annihilate the late Captain James B. Eads' great work, undertaken at the risk of his own fortune, and creating upon the same principles which guided our Krayenhof and his followers, and which are still pursued by the Waterstaat, the deep-water canal into sea. Outlets, as proposed, are only palliatives, and, let me add, bad palliatives, which can only afford temporary relief, but if raised to a system will irretrievably spoil one of the finest waterways of the world, which should have its own well-defined summer-, winter- and inundation-bed, unencumbered by levees, dykes, embankments, dams, etc. The Father of the Waters should have a road-bed regularly increasing in capacity from his source to his mouth, with as few curves as possible, and those which cannot be removed should be made as easy as possible. The roadbed should lead directly into sea without sideways-tappings, outlets, etc. It should have sufficient capacity to discharge the waters which the mountains pour into it, in ordinary as well as extraordinary times.

If it were my business I should put the whole basin of the Mississippi under special hydrographic control. The following would be the scheme I should propose.

At the head there should be a chief-inspector, preferably, but not necessarily, an engineer; but an engineer with broad views, not going into details, but one who understands that his embankments, his walls, his canals, are not the ends, but the means to get at the ends; an engineer with a knowledge of practical political economy; with a clear insight in agricultural matters. He should have talent for organizing and executive ability. The choice will be difficult, but is it impossible? No, I believe not. I just mentioned a name, the bearer of which should have been the ideal man in such a place. Eads should have been chief inspector of the great Mississippi. Alas, he is no more! But I have no doubt that there are others who have the needful talents.

The chief inspector should have his staff; besides engineers, it should number within its ranks an agronomer, a physician, or let me rather say, a hygienist, a forester and a jurist.

The whole basin should be divided into three great divisions: the mountain, the navigable, and the mouth division, each under a separate inspector, acting under the command of the chief inspector. The second and third divisions should, of course, be controlled by one of the engineering profession, but the first, the mountain division, should be controlled by a forester, assisted by a staff in which the engineering profession, of course, should not be absent.

The divisions should be cut into sections and under-sections, each with its respective chief.

The chief inspector, acting directly under the Government, should be given ample power.

His duty should be, in the first place, to chart the whole basin from a hydraulic point of view; to establish the great river and each of his confluent's summer and winter régime.

This should be the base of his proposal for controlling the river; perhaps in this part of his business he might take some lessons from the work of the Kräyenhofs, the Calands, etc., but also from the commissioners of the Clyde, Tyne and other British rivers, from the Donau Committee, etc.

The proposal should include the engineering, administrative and legislative measures for controlling the river.

He should afterwards have to make a working plan with budget, say for the next ten years, with a program for the next; and, lastly, he should have the control of the works in execution.

In this way there would be unity of aim, unity of action. Private interests will be regarded, but become subordinate to public welfare.

From other sources than the *Journal* I know that especially the Lower Mississippi suffers from individual arbitrariness and absence of centralization, but Professor Haupt's article has confirmed me in my supposition. The river needs a central administration. It suffers from the same causes as the Netherlands' river system. It requires the same administrative and technical remedies.

But although as badly spoiled as the Rhine, Meuse and Scheldt in former centuries, perhaps still worse, the task of improving its conditions, although a difficult one, has fewer difficulties to contend with than the Netherlands' engineers, when controlling the above-named rivers. They had to contend with factors which, at least in the Mississippi's lower reaches, do not exist: with ice and its disastrous effects. Besides neither of these rivers has its course wholly within the bounds of the realm, as is the case with the Mississippi. The Netherlands had no control over the forests at the origin; every one who has lived in a mountainous country is aware of the beneficial influence of forests upon a river's régime.

In the above I have briefly sketched my opinions about the manner of controlling the Mississippi, its floods, its mouth, its navigable canal and its banks, and hope I may accomplish some good. Perhaps you will ask what has induced me to publish my views in a matter with which I have nothing to do, what has induced me to meddle with other people's business? Well, gentle-

men, I should answer: it is a technical question, and this is always one interesting me. Besides that, I have always felt a great sympathy for your great commonwealth, and as the Mississippi basin is the greatest in your republic, and millions depend upon its good condition, I could not refrain from giving my views, when I saw that your engineers are on the wrong trail, and to show you what, in my view, is the right one.

Respectfully yours,

H. VAN MEERTEN.

BITTENZORG, JAVA, December 19, 1903.

P. S.—I beg to add to the above, that the monthly illustrated paper *Eigen Haard* (Own Hearth), edited at Amsterdam, contains many well written articles in popular style about Krayenhof, Caland, the Conrads and their works; but for real technical information one should consult the great works about "Waterbouwkunde" and the proceedings of the "Koninklijk Instituut van Ingenieurs."

To the Committee on Publication.

GENTLEMEN:—The paper submitted by the distinguished Dutch engineer, printed herewith, is of great interest for its valuable digest of the evolution of the great works of drainage, reclamation and navigation at the mouths of the Rhine, the Meuse and the Scheldt, which so united their waters as to form a labyrinth of islands and channels which were submerged at high waters and rendered navigation very difficult.

In the comments made on the methods proposed for the regulation of the floods of the Mississippi, he attempts to apply the methods in vogue in Holland for *reclamation* to those proposed in the United States for *navigation*, and suggests that if, the excess of flood waters is permitted to escape, the country will become a place for the abode of reptiles and the generation of deadly fevers.

It may seem proper, therefore, to call attention to the fact that in the improvement of rivers, the plans must be governed by the characteristics and conditions which prevail at the locality. It does not meet the case to cite precedents which are so wholly dissimilar as the Rhine and the Delta of the Mississippi. The former lies in 52 north latitude, where ice plays an important part in the obstruction of the mouths, whereas the passes of the Mississippi are near the Tropics and, therefore, exempt from ice. Moreover, the tides, an important factor in the creation of a navigable channel, vary from 5 to 12 feet at the North Sea outlets, while on the Gulf of Mexico they seldom reach 2 feet.

The discharge of the fresh-water floods of the Mississippi through the main outlet, passing New Orleans, may exceed 1,000,000 cubic feet per second, while that on the Holland rivers is very small, and the tides are depended upon to maintain the depths. Neither is there any comparison as to the relative amount of the sediment carried to sea by these two streams, a factor of the greatest importance. The lessons of the works and experiences in Holland would, therefore, not seem to be particularly applicable to the problem of protecting the Mississippi or of improving its navigation, excepting as to the durability and form of the dikes and the character of their materials, all of which have been of great service to mankind.

But while objecting to the relief of the Mississippi by means of outlets, the distinguished writer states that it was found necessary at the mouth of the Rhine, to construct sluices and an artificial canal to "discharge its superfluous water into the North Sea," and thus the Rhine was regulated "by giving it an independent outlet through the mouth of the Nieuwe Maas, and afterwards the Maas was regulated and got its independent roadbed and mouth through the Oude Maas and Bokkegat . . . last, not least, a new mouth was dug at the Hoek van Holland, and the old mouth was dammed up and closed. Disastrous floods are now a thing of the past."

In other words, it is evident that as the floods of Holland are derived mainly from the sea, the remedy most effective there was to dam them out and create artificial channels to provide for navigation through them, but it will be seen that this plan of improvement would be wholly inadequate and ruinous when the flood comes from the interior, so that to place obstacles to its rapid voidance at the natural mouths of the river would be fatal, not only to the navigation, but to the entire country.* As an illustration, the writer refers to the relief afforded by the admirable works constructed by the late Capt. Jas. B. Eads, at the South Pass, between 1874 and 1879, which resulted in opening that pass, but it should also be a matter of record that to secure the depths required under his contract the original jetties were contracted by spurs, and finally by a second set of lateral dikes until the channel was reduced to about 600 feet in width, and that this over-contraction, acting as a partial dam, is causing the entire pass to foul, so that the bed is rising at the rate of nearly 5 inches per annum, and a contract has been let for the opening of the Southwest Pass by two jetties, which vary in width from 3,500 feet at the outer end to about 6,000 feet at the shore, while the pass itself is but about 1,300 feet wide.

This outlet discharges 41 per cent. of the water which reaches the head of the passes, and yet previous Boards have found that in the main reach of the river above its junction with the Red, the normal width to secure a limited depth for low-water navigation should not exceed 3,000 feet. But there is not space to discuss this important question in detail, suffice it to refer to the Report of the Mississippi River Commission for 1903, as to the results secured since its creation in 1879, wherein it states:

"Systematic work, which has for its object to permanently locate and deepen the channel, has not been practicable under existing conditions. In the limited extension and repair of bank protection and contraction work the Commission has, however, kept in mind that the permanent improvement of the river is contemplated by the organic act, and experiments are continually being made looking to the best use of available material and the development of appliances and methods which may be economically and effectively employed when Congress shall provide for such a systematic improvement."

In a river carrying the enormous quantities of sediment which encumber the Mississippi, the problem is largely one of eliminating the solid material and depositing it beyond the channel. This cannot be done by confining it to

* Let the waters of a river overflow, and it will bring life to meadows and pastures; but if you dam it back it will eventually burst through its banks, a destructive torrent of mire.
—*Count Leo Tolstoy.*

the bed and requiring the water to transport it to the mouth, where it must be ejected in front of the stream, thus rapidly extending it gulfward and reducing the slope. It is found that at the two lateral outlets known as Cubitt's Gap and the Jump the river has deposited about 150 square miles of sediment in thirty years, reclaimed that much land and the navigable channels have not been impaired. To have accomplished this by dredging would have cost about \$1,500 per acre. By this process of hydraulic grading it cost nothing.

But recurring to the experience of the Dutch engineers, in the effort made to regulate the floods by dikes, the record states: "That the rivers cannot at all times, any more than the sea, be kept under control by the dykes, is shown by the floods of 1775, 1776, 1784, 1799, 1809, 1820, 1861, etc." (*Enc. Brit.*, Holland, p. 65.)

That the creation of a free discharge near the mouth to void the floods rapidly would not injure the works of Captain Eads, as alleged, is demonstrated not only by the large crevasses which existed when his jetties were constructed, but by the Pass a Loure crevasse, which has been in existence since 1891. Moreover, streams do not deposit on a falling stage so readily as during a rising one, resulting from the reduction of velocity by obstacles placed in their paths.

The author of the paper fears, therefore, that his methods have not been thoroughly understood by his friend in far-off Java, or probably that the latter has not given due weight to the sediment problem and the need of separating it from the water of the stream wherever it may be possible by permitting the natural hydraulic motor to eject it beyond its navigable channel, instead of depositing it in its bed to obstruct both the discharge of its waters and the passage of its commerce.

For a more elaborate discussion reference is made to a paper read at the annual convention of the American Association for the Advancement of Science, at St. Louis, December 28, 1903, and published in the *Proceedings* of the American Philosophical Society of Philadelphia, 1904.

LEWIS M. HAUPT.

PHILADELPHIA, March 2, 1904.

Annual Reports of the Schools of Drawing, Machine Design and Naval Architecture for the Sessions of 1903-1904.

THE DRAWING SCHOOL.—This school is an excellent indication of the condition of the engineering industries, and shows the ups and downs of the demand and supply of draughtsmen and technical workers to a remarkable extent. The last few terms have been the crest of the wave, and this spring term has shown the receding tide. Although the falling off has been slight, the indication is there, nevertheless.

But there is a compensation for this in that the best students utilize the dull times to increase their knowledge and to prepare themselves for the increased demand which is sure soon to return. Consequently, in dull times

the school is full of serious workers, bent upon making the most of their spare time, when they can combine work at school with work at home, and thus get the very most from the opportunities offered.

WM. H. THORNE,
Director.

THE FOLLOWING STUDENTS HAVE DESERVED HONORABLE MENTION :

In the Senior Mechanical Class.

Ross Rodgers,	Chester D. Thorpe,
Walter Baylie,	William A. Janton,
J. Monroe Bowen,	Clarence N. Haven,
Walter D. Williams,	James L. Scanlin,
William Derr,	Albert F. Heeley,
George Moxley,	James P. Conway,
Herman Fink,	Philip Hochman.

In the Intermediate Mechanical Class.

Walter T. McGrath,	Herman Sangtinetti,
E. Carman Gardiner,	Arthur Sherbourne,
James McCairns,	H. Nelson Poole,
Charles Harrison,	John Reilly,
Thomas F. Kelley,	Irenée P. Pedrick,
	Charles W. Pfeiffer.

In the Junior Mechanical Class.

John G. Collins,	P. Saltzmann,
Merwyn McKnight,	David B. Robinson,
H. L. Schwenk,	Frank H. Shepherdson,
G. Hollinger,	Frederick Graff Groves.

In the Architectural Class.

William N. McCully,	Harry Stull,
Horace Tomlinson,	Charles Wilson.

In the Free Hand Class.

David Bowers,	Gustav D. Lemmerman.
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THE FOLLOWING STUDENTS ARE AWARDED SCHOLARSHIPS FROM THE B. H. BARTOL FUND, ENTITLING THEM TO TICKETS FOR THE NEXT TERM :

Arthur J. Beuter,	Joseph Hadik,
Charles W. Leeds, Jr.,	Charles Huegle,
J. Crankshaw,	Valentine Huegle.

THE FOLLOWING STUDENTS, HAVING ATTENDED A FULL COURSE OF FOUR TERMS, WITH SATISFACTORY RESULTS, ARE AWARDED CERTIFICATES :

Ross Rodgers,	James Taylor,
J. Monroe Bowen,	Harry Groben,
Walter D. Williams,	George Muth,
William Derr,	John H. Wackenhut,
George Moxley,	E. N. Hannum,
Herman Fink,	Robert H. Pickering,
Albert F. Heeley,	John P. Knapp,

Chester D. Thorpe,
 William A. Janton,
 James P. Conway,
 James L. Scanlin,
 Gomer W. Hagstrom,
 Norton Fleu,
 J. Alten Whitecar,
 Fred. Randle,
 Mark F. Ruhe,

Clarence Brown,
 Edward A. Collins,
 John Ridgway,
 Charles Ludwig,
 Philip Hochman,
 Horace Tomlinson,
 Daniel R. Finkbiner,
 Arthur Friant,
 William N. McCully,

H. Nelson Poole.

THE TIOGA BRANCH DRAWING-SCHOOL.—We have had a considerable increase in the number of students during the past year, and for this reason have been compelled to seek new quarters, located at Kenderton Hall, Seventeenth and Venango Streets, Tioga. This place has double the capacity of our former school, but we find that our space is already getting crowded and our present trouble is to obtain a suitable building large enough to accommodate all applicants, and at a rental within the means of the school.

We are pleased to say that this year has been the most successful in regular attendance, neatness and accuracy of work. The increased interest shown by the manufacturing concerns in this locality in recommending their young men to attend drawing-school has also been very gratifying. We also beg to offer our thanks to the George V. Cresson Company and Midvale Steel Company for the financial support extended by them, without which we would not have been able to carry on this work.

H. E. NORBOM,

Director.

NAMES OF GRADUATES, FRANKLIN INSTITUTE BRANCH SCHOOL,
 SPRING TERM, 1904:

Walter Andrew,
 Harry L. Harley,
 Charles W. Ritzer,
 Thomas K. Berry,
 Thomas V. Burke,
 John W. Duval,
 Anders F. Forsstrand,
 Thomas C. Haskins,

George W. Nise,
 William Gregson,
 Robert A. Hemphill,
 Samuel Mason,
 Alfred W. Hendershot,
 Harry V. Tarbuck,
 James B. Riley,
 J. Aloysius Thompson,

John J. Melloy.

THE SCHOOL OF MACHINE DESIGN has just completed a successful year. Though the attendance has not been quite up to that of last year, those who did attend did so regularly, and gave evidence of being deeply interested in the work. Owing to the limited number of applicants for the courses in "Kinematics of Machinery and Machine Design," these were omitted last year, but we have good prospects of having a class in these subjects next year, and they will be taught as heretofore.

Two scholarships were awarded in the algebra class. The first, which entitles the holder to one year's tuition at the Institute, was given to the student obtaining the highest average in the examinations for the winter and spring terms. The second, which entitles the holder to one term's tuition, was given to the student having the second highest average.

We believe, from the experience of the closing season, that these rewards have a stimulating effect upon the students, and that it would prove of great benefit to the School of Machine Design if we had a fund such as that endowed by the late B. H. Bartol for the benefit of the Drawing School.

The classes in geometry and trigonometry have been under the direction of Mr. Clayton Worrall, and have been well prepared for the more advanced work next year. Mr. Yeats, a man of wide experience as a teacher, has ably assisted with the algebra.

The classes in Theoretical Mechanics and Strength of Materials have been well attended, and the students have now a good working knowledge of the design of beams, columns, shafts to withstand torsion, etc. In addition to this they have taken up the fundamental principles of graphical statics, and have drawn the stress diagrams for a number of roof trusses.

The following students have passed the examinations, their names, reading across columns, being arranged in order of merit.

L. M. ARKLEY, *Director*.

Mechanics.

F. E. Fisher,	M. O. Stilson,
F. B. Wetherill,	E. Schmeltzer,
C. Fithian,	Thos. Jones,
Geo. Keefe,	J. C. Warren.

Strength of Materials.

M. O. Stilson,	C. Fithian,
Thos. Jones,	J. C. Warren,
E. Schmeltzer,	F. B. Wetherill,
Geo. Keefe,	F. E. Fisher.

Geometry.

Fred. Ruch,	Wm. Fulmor,
* A. Cramp,	* E. Kirchuebel,

* L. W. Krout.

Trigonometry.

Fred. Ruch,	Wm. Fulmor,
E. Kirchuebel,	A. Cramp,

L. W. Krout.

Algebra.

D. Brierley,	Wm. McGonigle,
W. Magann,	F. S. Hodge,
C. Bockius,	J. Long,
S. Dougherty,	J. A. McLean,
R. Morrison,	A. Armitage,
A. Forstrand,	E. Stranahau.

D. Brierley is awarded the first scholarship ; Wm. McGonigle the second.

* Those marked with the asterisk obtained the same number of marks.

SCHOOL OF NAVAL ARCHITECTURE.—I have the honor to report that the School of Naval Architecture has met with decrease in its enrollment from last year, owing to the local depression in shipbuilding, but the average attendance of the senior division students during the winter term was 98·6 per cent., and for the spring term 98 per cent., the majority of this division making the full attendance; that of the junior division was 90 per cent. for the winter term and 80·6 per cent. for the spring term. Eight of the senior division have attended the full term of two years and, having passed the examinations, will be graduated.

The senior class in Practical Naval Architecture has studied the various details in construction of the different classes of vessels, making sketches and calculations for the same. In Theoretical Naval Architecture they have calculated weights of material, centers of gravity, strength of structure of the hull under varied conditions, trim, stability, etc. Their home work has shown wonderful energy, considering that the drawings, etc., are made without the usual adjuncts of a drawing office. In fact, this class has exhibited more than ordinary intelligence and its members are above the average, being neat and painstaking.

The junior students have progressed rapidly in both theoretical and practical naval architecture, and have also shown marked zeal in their work in class and at home. Numerous drawings beyond the average in neatness and accuracy have been made from blue-prints lent for that purpose.

ALEX. J. MACLEAN, *Director*.

Philadelphia, April 22, 1904.

THE FOLLOWING STUDENTS ARE AWARDED CERTIFICATES:

Charles C. Brush,	Fred. C. Griggs,
Henry A. Burkholder,	Luther W. Krout,
Robert Deichmann,	James C. Vanderslice,
Theodore H. Gloeckner,	Reginald H. Waters.

THE FOLLOWING STUDENTS ARE ENTITLED TO HONORABLE MENTION, HAVING ATTENDED ALL SESSIONS AND SHOWN GENERAL EFFICIENCY:

J. W. Sutton,	H. A. Burkholder,
Theo. H. Gloeckner,	C. D. Wallack,
J. C. Vanderslice,	H. C. White,
L. W. Krout,	R. Waters,
A. S. Reed, Jr.,	Lionel Levy,
Jos. McDermott,	I. Aarum,
Chas. C. Brush,	Fred. C. Griggs,
Chas. McMenamin,	Jas. B. Baker, Jr.,
C. M. Andrews,	Elmer Hicken.

Notes and Comments.

THE LIGHT ALUMINUM ALLOYS.*

BY JOSEPH W. RICHARDS.

Chromium hardens aluminum strongly. The chromium-aluminum alloys have somewhat of the qualities of self-hardening steel, retaining their hardness on heating or after annealing. The use of 2.3 per cent. chromium is recommended; 11 per cent. makes a brittle alloy. Chromium-aluminum alloys are being used commercially. Titanium-aluminum alloys are difficult to make and have practically gone out of use. Alloys of aluminum and manganese, up to 5 per cent. manganese, are hard and rigid. When used with copper and nickel manganese makes the hardest light alloy yet produced. The manganese should be employed in the form of a rich aluminum-manganese alloy produced in the electric furnace. The alloys of aluminum and tin are not much used. Tin makes aluminum whiter and more easy to solder. The aluminum-silver alloys are harder, stronger and whiter than pure aluminum, take a higher polish and retain it better than pure aluminum. They are used for making table ware and ornamental articles. The alloys of nickel and aluminum have not yet been found useful. The commercial alloys which go under the name of "nickel-aluminum" are really alloys of aluminum with nickel and copper; when made for rolling, they contain from 2 to 5 per cent. nickel and copper together, the larger proportion being usually copper. The plates of the yacht "Defender" were made of this alloy. The precise effects of tungsten on aluminum have not been satisfactorily determined. An aluminum alloy containing a small amount of tungsten has been used extensively for military equipments. Aluminum alloyed with 2 or 3 per cent. of German silver gives a strong, tough metal which is easily made. An aluminum alloy containing 10 per cent. magnesium is being used in Europe. Zinc is the cheapest and one of the most efficient metals with which to improve the mechanical qualities of aluminum. Up to 15 per cent. zinc, these alloys are malleable; in castings as much as 33 per cent. zinc may be used. Casting in chills gives better results than in sand. The zinc-aluminum alloys are made by melting aluminum and adding zinc thereto. The 15 per cent. alloy can be rolled and drawn. The 33 per cent. alloy, sometimes called "Sibley casting alloy," is extremely rigid, but is not so resistant to shock as the alloys containing less zinc.

In the preparation of aluminum alloys the best results are obtained by the use of pure metals, this being especially the case with respect to zinc. In general, the aluminum should first be melted, the other metal being subsequently stirred in. The melting can be performed in an ordinary graphite crucible, but magnesia-lined crucibles are best for this work. In alloying, recovering of charcoal is needed; but simply for melting, no covering is required. It is important that the metal should not be overheated; it is of the greatest importance that it should never be over a cherry-red. A wrought-

* Notes from a paper read before the American Society for Testing Materials, at Delaware Water Gap, July 3, 1903.

iron stirring rod may be used, but a carbon rod with an iron pipe for a handle is better. The alloys should be allowed to cool down before pouring. The use of a flux in melting is not recommended. For general castings, green sand is suitable. Large gates, heavy feeders and numerous air vents are necessary. Slabs and rods for rolling or drawing are cast in chill molds, as the metal is soft, uniform and stronger than if cast in sand, and the surface is smoother. Since the alloys are hardened and stiffened by working, they must be annealed frequently during rolling. Slabs or billets are best broken down by a steel hammer while at temperature of 150° to 250° C.; steel rolls with good surfaces should be used, and the rolls should be at temperature of 150° to 200° C.

ASPHALT IN THE INDIAN TERRITORY.

In view of the fact that 7,239 acres of asphalt land in the Indian Territory will be disposed of at public auction in a few months, it may be interesting to many people to know something about these deposits. Over 2,000 acres of these lands are in the Tishomingo quadrangle, which has been surveyed, topographically and geographically, by the United States Geological Survey. Mr. Joseph A. Taff is the author of the geologic folio which was recently published as a result of these surveys. In this he gives a detailed description of the asphaltic deposits of the quadrangle.

Those deposits which are of economic importance are found in the vicinity of Gilsonite, near the northwest corner of the quadrangle. They occur chiefly as impregnations in the sandstones, limestones, conglomerates, and grits of three distinct geologic formations.

Bituminous sandstone.—The richer bituminous sandstone contains 7 to 12 per cent. of bitumen, and grades outward into the barren sand in peculiar ways. In some instances the bitumen occurs in layers or streaks parallel with the bedded structure and alternating with the purer and, at present, porous sand. There are at least five acres of economically valuable bituminous sandstone in the vicinity of Gilsonite. Four of these are in the Tishomingo quadrangle and the fifth is just beyond its border, on Rock Creek, 2 miles a little north of west from Gilsonite. In the mine at Gilsonite the impregnations of bitumen have entered some of the associated siliceous and fossiliferous limestone layers. A second area of bituminous sandstone occurs nearly a half mile west of Gilsonite. In the N. W. $\frac{1}{4}$ of section 22, T. 1 S., R. 3 E. there is a third area of bitumen impregnating the sandstone. Here there are three quarries, known as the Kirby mines. The fourth area of the bituminous sandstone in the quadrangle is in the eastward extension of the same sandstone member as that in which the Kirby mines are located. The two mines located in the bituminous sandstone of this area occur half a mile north of Gilsonite, in the south side and west end of a low ridge capped by a heavy limestone conglomerate. The fifth and least valuable bituminous sandstone deposit known in this vicinity occurs at the base of the high bluff in Rock Creek, near the southwest corner of Section 21, T. 1 S., R. 3 E. Only a small area of the highly bituminous sandstone occurs here.

Bituminous limestone.—The better grade of bituminous limestone carries 5 to 6 per cent. of bitumen. It occurs in two areas, one at Gilsonite and the

other 1 mile to the southwest. Two mines have been located upon the bituminous limestone 1 mile southwest of Gilsonite. The larger of these is at the extreme west end of the Viola limestone ridge and the other on the crest about 600 feet farther east. The bituminous limestones are most advantageously situated for economical mining, being in a bluff 50 feet high, at the terminus of the ridge where the rocks are steeply tilted southward, exposing more than 300 feet of strata. Of the 340 feet of bituminous limestone at this locality, 128 feet in the lower part contain 5 to 6 per cent. of bitumen.

Bituminous rocks in Carboniferous conglomerate.—Certain beds about half a mile west of Buckhorn contain the richest bituminous deposits known to occur in this field. The bituminous and associated beds consist of conglomerate, grits, shale and limestone interstratified. The richest bed, which is locally conglomerate at the base and about 10 feet thick, will produce approximately 14 per cent. of bitumen.

This Folio (No. 98) may be obtained for 25 cents from the Director of the United States Geological Survey, Washington, D. C.

NEW IRON-NICKEL ALLOYS.

Two of the remarkable alloys discovered by Dr. Guinaume in his study of high nickel and iron compounds are now made on a commercial scale. The first, to which the trade name "Invar" has been given, contains 37 per cent. of nickel, and after special heat treatment is practically unalterable in length between the ordinary ranges of atmosphere temperature, the dilation per degree Fahrenheit being only 1-36 inch per mile. This is coming into use for standard bars, wires for base line measurements, and other geodetic purposes, as well as for the pendulum rods of astronomical clocks and the compensation balances of chronometers. The alloy containing 46 per cent. of nickel, known as "Platinite," has the same coefficient of expansion as glass, and may, therefore, be substituted for platinum in the manufacture of incandescent electric lamps. It has also been used in Appert's armored glass, in which a wire network is inclosed between two plates of glass.—*Iron Age*.

TIN IN ALASKA.

The outlook for tin mining in Alaska is improving. Lode tin has been found in the Lost River district, about 30 miles east of Cape Prince of Wales. The tin occurs in a dike of granite traversing limestone. Prospecting is now going on at this locality and the outlook appears to be good. The reconnaissance work of the United States Geological Survey indicates that the distribution of tin in the Seward Peninsula is wider than supposed, although the occurrence of placer tin has only been proved in the creeks at York, and in the valley of the Snake River, 100 miles east of York and about 20 miles inland from Nome. The cassiterite is grayish brown to black, and is more often confused with magnetite than with garnet. Even tourmaline has been mistaken for tinstone by prospectors unfamiliar with the mineral. With better knowledge and more extended search, it is likely that the United States may again include tin among its important metallic products.—*Engineering and Mining Journal*.

Book Notices.

Present College Questions : Six papers read before the National Educational Association, at the sessions held in Boston, July 6 and 7, 1903. By Charles W. Eliot, President of Harvard University ; Andrew F. West, Dean of the Graduate School, Princeton University ; William R. Harper, President of Chicago University ; Nicholas Murray Butler, President of Columbia University. 8vo, pp. viii + 105. New York : D. Appleton & Co. 1903. (Price, \$1.00.)

This collection of six addresses presents the views of representative men prominently identified with higher education in America, on a number of debatable questions affecting the future of the American college.

The following subjects are discussed : A New Definition of the Cultivated Man (Eliot) ; the Present Peril to Liberal Education (West) ; the Length of the College Course (Eliot, West, Harper, Butler). W.

Die Herstellung der Akkumulatoren. Ein Leitfaden. Von F. Grünwald, Ingenieur. Mit 91 in den Text gedruckten Abbildungen. (3te Auflage.) 12mo, pp., viii + 158. Halle a. S.: Druck u. Verlag von Wilhelm Knapp. 1903. (Price, 3 marks.)

The work above named treats concisely of the following subjects : The generation and action of the voltaic current ; the development of the lead accumulator and the conditions governing its construction ; the materials of the lead accumulator and their treatment ; the behavior and handling of accumulators ; application, shunting and operation of accumulators ; official regulations and data. The illustrations are numerous. To those familiar with the German, the work should prove a useful reference book. W.

The Mechanical Engineer's Pocket-Book of tables, formulas, rules and data. A handy book of reference for daily use in engineering practice. By the late D. Kinnear Clark, M. Inst. C.E., etc. (5th edition, revised throughout and enlarged.) By H. H. P. Powles, M.I.M.E., A. M. Inst. C.E. 12mo, pp. xxxii + 602. New York : D. Van Nostrand Co. 1903. (Price, \$3.00.)

The various reference books edited by the late Mr. Clark have for years enjoyed a standing among the engineering fraternity second to none in the English language, being equally well known and esteemed on both sides of the Atlantic.

The work above named is issued in handy pocket-book form, and contains formulas, rules and data covering every topic of importance that will be likely to engage the attention of the mechanical engineer. The circumstance that much of the work is founded on English practice, so far from detracting from its utility to American engineers, will in many cases make it of special value to them, as it will usefully supplement the many American pocket-books.

The present fifth edition of the book has been carefully revised by the editor and brought up to date. This is especially true of the section relating to Electrical Engineering. W.

The American Steel Worker. A twenty-five years' experience in the selection, annealing, working, hardening and tempering of various kinds and grades of steel. By E. R. Markham. First edition. 8vo, pp. 343. New York: The Deery-Collard Company. 1903. (Price, \$2.50.)

Except Byrne's universally-known "Metal Worker," the reviewer can call to mind no practical guide book that can compare, favorably, with Mr. Markham's book as a practical guide and instructor for the artisan.

The author takes up successively the various manipulations of forging, hardening, tempering, welding, etc., with which the skilled steel worker must be familiar, and describes in the most minutely detailed manner every step of these processes. Not only this, but what perhaps is of equal value, he culls from the store of his great experience the numerous difficulties that beset the inexperienced hand, and illustrates, by precept and example, the numerous errors that must be avoided to achieve success.

The conversational style adopted by the author is admirably adapted for his purpose of imparting advice and instruction to practical men. The publishers, also, have done their part of the work well, the printing and illustrations being unusually good.

W.

Traité Theoretique et Pratique des Moteurs à Gaz et à Pétrole. Par Aimé Witz, Ingénieur des Arts et Manufactures, Docteur ès Sciences, Professeur à la Faculté Libre des Sciences de Lille, etc., etc.; 4^e édition, refondue et entièrement remaniée. Tome ii (4to, pp. 505-1135). Paris: E. Bernard, Imprimeur-Editeur. 1904.

The present volume constitutes the second part of the exhaustive treatise of M. Witz, the first portion of which was noticed in the *Journal* about a year ago. This volume is devoted specially to a detailed description of the construction and operation of the principal exemplars of the several types of gas and petroleum engines. The engineer who is seeking information on this subject will find in this work, in which the text is admirably supplemented by engravings of every needful detail of construction, a mine of useful information.

The two volumes of the work make perhaps the most complete monograph on oil and gas engines that has thus far appeared.

W.

Photographic Lenses. A simple treatise. By Conrad Beck and Herbert Andrews. Second edition. (16mo, pp. 320.) London: R. & J. Beck, Ltd., and Percy Lund, Humphries & Co., Ltd. New York: Tennant & Wood. 1903. (Price, cloth, 75 cents; de luxe, \$1.00.)

The character and scope of this booklet are accurately described by the title. It is the work of two practical lens-makers, and is intended to serve as a practical guide for the use of the practical photographer, who, without the opportunity or desire to master the subject of photographic optics, wishes to be able intelligently to choose the lenses best adapted for his requirements, and to use them to the best advantage. This is the kind of information which the book covers, and presents in readily comprehensible language.

The book is profusely illustrated with diagrams and with half-tones, showing by comparison the results obtained by the use of different lenses. A convenient feature is a marginal index of topics.

W.

Thonindustrie Kalender, 1904. 12mo, pp. 762. (II Theil.) Verlag der Thonindustrie Zeitung. Berlin, 1904.

This useful handbook is designed primarily as a general reference book for the use of German industrials engaged in the affiliated clay industries—the producers of raw materials, manufacturers of cement, bricks, tiles of every description, refractory materials, drain pipes, pottery, etc., etc.

It covers also the construction and operation of kilns and furnaces, the special machinery employed in the art, steam machinery and appliances, and, in brief, every topic that might be supposed to interest the clay worker.

W.

Die Elektrometallurgie der Alkalimetalle. Von H. Becker. Herausgegeben von "L'Industrie Electrochimique." (Mit 83 Figuren und 3 Tabellen im Text. 8vo, pp. viii + 135. Halle a. S.: Verlag von Wilhelm Knapp. 1903. (Price, 6 marks.)

This timely publication constitutes Volume IX of the series of "Monographs on Applied Electrochemistry" now appearing from the press of the above named publisher. The author first treats of the chemical methods of producing the alkali metals; then takes up the modern electrochemical methods, treating these under two divisions—Electrolytic and Electrothermic.

It should prove a useful reference work to all who are interested in the subject

W.

Franklin Institute.

[*Proceedings of the stated meeting held Wednesday, April 20, 1904.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, April 20, 1904.

MR. H. R. HEYL in the chair.

Present, 138 members and visitors.

Additions to membership since last report, 13.

Mr. Herbert L. Heyl was unanimously elected as Trustee of the Elliott Cresson Fund, in place of Mr. S. Loyd Wiegand, deceased.

Mr. M. R. Hutchinson, of New York, gave a description of the Hutchinson System and Apparatus for the Alleviation of Deafness, and the Instruction of the Deaf-Mute.

The speaker illustrated his remarks with the aid of numerous lantern photographs, and gave a most interesting demonstration of the application of several forms of his apparatus, using as subjects several of the children—pupils of the Philadelphia Institution for the Deaf and Dumb. The subject called forth considerable discussion, participated in, chiefly, by Principal Crouter and several of the instructors of the Institution named above, and the speaker.

The subject of Mr. Hutchinson's inventions was referred to the Committee on Science and the Arts. After a vote of thanks to the speaker the meeting was adjourned.

WM. H. WAHL,

Secretary.

Sections.

[*Abstracts of stated meetings.*]

ELECTRICAL SECTION.—*Stated meeting*, held Thursday, March 31, 8 P.M. Mr. Thomas Spencer in the chair. Present, 122 members and visitors.

Dr. Lee de Forest, of New York, representing the De Forest Wireless Telegraph Company, read a paper on "Wireless Telegraphy." The speaker gave a brief sketch of the various systems that have been suggested and (in some cases) put in actual service, and devoted the remainder of his remarks to a description of the system which bears his name and which is at present in successful operation.

The paper was discussed by Messrs. E. A. Scott, Carl Hering, Dr. E. Goldsmith, Prof. G. A. Hoadley, the Chairman and the author. (The paper, with discussion thereon, will be printed in the *Journal*.)

The thanks of the meeting were voted to Dr. De Forest.

RICHARD L. BINDER,
Secretary.

SECTION OF PHOTOGRAPHY AND MICROSCOPY.—*Stated meeting*, held Thursday, April 7, 8 P.M. Dr. Henry Leffmann in the chair. Present, 98 members and visitors.

Prior to announcing the communications of the evening the chairman called attention to several exhibits which were of more than usual interest.

The first of these consisted of several specimens of the "Parallax Stereograms" of Mr. Fred. E. Ives. This optical device was originally exhibited several years ago at one of this Section's meetings, but has since been improved, and is now being commercially exploited.

The second exhibit consisted of specimens of photographs in natural colors of natural objects and of paintings made by a photographic process devised by Messrs. M. Miley & Sons, of Lexington, Va.

The resulting photographic prints exhibited surprisingly close approximations to the coloring of the originals and were much admired.

The regular communication of the evening, "Microscopic Studies with the Moving-Picture Camera," was a highly interesting demonstration, showing many minute living organisms, etc., that had been magnified many times by the microscope and then photographed by the method used in making moving pictures. Among a number of subjects thus exhibited, the circulation of blood in the web of the frog's foot, and the circulation of cell fluid in living waterweed, are specially worthy of notice.

The exhibits were explained and commented on by the chairman, and, at the close of the meeting, the thanks of the meeting were tendered to Mr. S. Lubin, of Philadelphia, who supplied the material and moving-picture camera for making the demonstration.

M. I. WILBERT,
Secretary.

JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,
FOR THE PROMOTION OF THE MECHANIC ARTS.

VOL. CLVII, No. 6. 79TH YEAR. JUNE, 1904

THE Franklin Institute is not responsible for the statements and opinions advanced by contributors to the *Journal*.

THE FRANKLIN INSTITUTE.

Stated Meeting, held Wednesday, November 18, 1903.

The Utilization and Disposal of Municipal Waste.

BY WM. F. MORSE, Sanitary Engineer, New York City, N. Y.
Member of the Institute.

Modern sanitation has for its purpose the preservation and prolongation of life by the enforcement of certain fundamental principles, or rules of action. These principles are, generally speaking, preventive in character; they aim to minister to the well-being and happiness of mankind by removing or modifying the causes of disease and discomfort.

Various methods of sanitary work which were formerly almost unknown have in the past quarter of a century made great advancement. Regulations against the pollution of the water supply; restrictions and oversight of the sale of foodstuffs; isolation and quarantine of infectious diseases; the use of antitoxin remedies; disinfection by steam and formaldehyde gases; the latest demonstrations of the con-

veyance of certain forms of fever by insects. These and many allied forms of research and discovery, practical or theoretical, are evidence of the enormous strides made in sanitary science in the past twenty-five years.

There is another practical and exceedingly interesting aspect of this work which affects the daily life of the great public both financially and physically, and which it is our purpose to briefly describe.

Every citizen, however large or small the community may be, is directly interested in the conditions that affect his health and comfort, and his pocketbook. When a street is badly paved, or unwatered or unswept, every passing person is aware of it and has a right to demand a remedy because he is personally concerned.

If we consider for a moment the enormous bulk of material brought into a city by the various agencies which are necessary for the daily support of life, and remember that after change and assimilation there remains a mass of effete and worthless matter, equal in amount to nearly 75 per cent. of the original quantity, we can begin to comprehend the difficulties of the problem of removing from the life of the people this great volume of waste. It is a problem that must be solved in a speedy and satisfactory manner, and one of great importance to the health of the city.

The waste of a community may be divided into two separate parts :

Organic.—All substances which are subject to decay and putrefaction, and in this condition objectionable and dangerous to health. This includes all forms of foods, and the bodies of animals, and may comprise sewage and the contents of vaults and cess-pools.

Inorganic.—Substances that are not subject to rapid decay and putrescence, but which may be exhausted by use and rendered worthless, such as ashes, street sweepings, refuse, rubbish and discarded household utensils and furnishings, and the waste from stores and factories. For convenience, these are included in the general term ashes, street sweepings and refuse, or rubbish.

Excluding sewage, which is conveyed away by under-

ground conduits, or which is taken from vaults by excavation and separately dealt with, and the carcasses of larger animals which are also separately collected and treated, we have remaining garbage, ashes, refuse and street sweepings, and it is our purpose to consider the disposition of these.

Divisions of City Waste.—Municipal waste, comprising garbage, street sweepings, ashes and refuse, or rubbish, is divided into the following approximate proportions:

	By weight. Per cent.	By volume. Per cent.
Ashes	65	47
Street sweepings	17	12
Garbage	10	10
Refuse	8	30

These figures, from the reports of the city of New York, apply in a general way to the larger cities where the same fuel is used. The whole proportion of municipal waste of New York City is about 4 pounds per capita per day. This is far larger than it is in the other large cities of the world; that of London is about 1·6–10 pounds, of Berlin 9–10 pounds, of Hamburg 1·1–10 pounds; in Philadelphia this proportion is 3·5 pounds per capita per day. But the local conditions in each city differ, therefore each city should be considered by itself, and the results obtained will be found to be governed by the circumstances peculiar to each.

Ashes.—The analyses of city ash show that about two-thirds are from households, and one-third from large furnaces, steam boilers, etc., where the coal used is of the smaller sizes and is more thoroughly consumed.

HOUSE ASHES.		STEAM ASHES.	
	Per cent.		Per cent.
Coal	25	Coal	15
Fine ash	50	Clinker	40
Clinker, slate	15	Fine ash	45
Rubbish	10		

When the fine ash is taken from steam ashes the residuum is of value for use as the basis of concrete for foundations, floors and fillings.

The disposal of these ashes upon dumps is an almost universal custom. Low ground is filled with mixed ashes and refuse, the admixture of matters liable to decay renders the

whole mass unsanitary and unstable ; floating clouds of dust rise with every wind, the whole neighborhood is littered with flying paper ; the odors and exhalations become a public nuisance, and the presence of putrescible matter and flies in summer threaten the health of adjoining property owners.

Street Sweepings.—Leaving out of consideration the removal of snow, which for present purposes will not be reckoned as part of the city waste, the sweepings from the streets claim attention. In a general way, the proportionate quantity for an average northern city with asphalt, block and brick pavings will be from 15 per cent. to 20 per cent. of the whole waste collection. This, of course, varies with the area of paving, the methods of sweeping and with the character of the population.

The component parts of street sweepings are approximately as follows :

	Per cent.
Moisture	35
Organic matter	30
Ash, sand, rubbish, etc.	33
Nitrogen, phosphoric acid, potash	02

There is undoubtedly value in street sweepings for land fertilization, as the percentage of organic matter and nitrogenous compounds is readily taken up by the soil, but the presence of nearly 50 per cent. of inert waste makes the cost of collection, transportation and application so large as to practically offset its value as manure. Experiments made on a large scale in several cities show that the street sweepings if delivered by short transportation direct to farms will be accepted and used, but no revenue to the city will result.

Sweepings can be destroyed by incineration, if furnaces of large capacity with forced draft are used, no fuel being needed. Taken in conjunction with other wastes sweepings may readily be burned, and will yield an equivalent in steam power. If dumped upon open lots and exposed to rain, there is inevitable putrefaction and consequent noxious odors.

Attention should be given to the fact that sweepings contain colonies of germs, or bacilli, that are dangerous to human life. In the experiments made under the direction

of the Commissioner of Street Cleaning of New York City, by the exposure of agar plates at the street level and 6 feet above, at various points in the city, and by noting the number of colonies of bacilli developed within a given time, there was found to be a maximum of thirty colonies per square inch gathered in the crowded streets of the east side tenement districts, the purpose of these experiments being to show the effects of traffic in distributing the bacteria in different air layers. A statement made by a leading specialist in the treatment of diseases of the head was to the effect, that after a dry season, followed by a brisk wind in New York streets, the increase of catarrhal and asthmatic diseases was very marked, and attributable to foreign organisms floating in the air.

Garbage.—The third division of municipal waste, comprising all the rejected and condemned food products from dwellings, shops and markets, the bodies of dead animals, and generally all that matter which by decay and putrefaction becomes objectionable, is known as garbage, and is approximately 12 per cent. in weight of the total waste collection.

The component parts of the average city garbage are as follows:

	Per cent.
Moisture	65
Solids	25
Foreign substances	06
Grease	04

Three or four methods for the disposition of this waste are in use: feeding to swine; dumping on low ground or into large bodies of water; plowing into ground; reducing, to extract the grease; and cremating.

Many New England cities practice the first method, maintaining through municipal ownership, or by contract, large farms where herds of swine are daily fed with the city garbage.

There are cases where a small amount of swill collected by private parties from hotels and fed when fresh can be safely and economically used; but when garbage remains in mass twenty-four hours in hot weather, fermentation sets

in, the liquids turn sour, and it becomes unfit for swine food. There are several cases on record where an epidemic of hog cholera has carried off the whole herd. The report of the State Board of Health of Massachusetts some years ago showed that trichinosis was developed in 17 per cent. of cases that were traced directly to the eating of hogs fed on the city garbage.

Dumping.—The deposit of large masses of garbage on ground in the vicinity of towns is universally condemned as unsanitary and positively dangerous. Numerous instances could be quoted of the inception and propagation of zymotic diseases from this source, instances that are too well supported to be questioned.

The statement of a former health officer of Philadelphia, made to the writer some years ago, was to the effect that many cases of diphtheria were traceable to the presence of exhalations from ground where large amounts of city waste had been dumped in former years.

When garbage is dumped into water, unless the conditions are specially favorable as to the prevailing winds and currents for the avoidance of the deposit of the material on neighboring shores, and the dumping is done far enough out to sea to prevent the choking of navigable channels, this method cannot be employed with success. With the exception of New Orleans and some western cities on the Mississippi, the custom has been abandoned.

Plowing into the Ground.—When fresh garbage is spread upon the surface of the ground, if free from metals and other foreign matters, it can be plowed under. On sandy soils this method has been attended by good results; but, as large areas of ground are infrequent in city neighborhoods, this is not an easy method to put into use. Moreover, this method of disposal cannot be employed in consecutive years. The ground does not oxidize and assimilate the charge fast enough to permit another charge for two or three years.

Reduction Process.—By this method the garbage is treated by a process of cooking, or steaming, separating it into fats or grease, water, and tankage, or residuum.

The special machinery used includes digestors, or cook-

ing tanks, presses, dryers, fume-destroyers, and condensers and mills for grinding the residuum. Being a trade process protected by patents and in the hands of close corporations, a knowledge of the exact methods, apparatus and results is not to be had. But the description of a plant erected in a neighboring city under the Arnold system gives a clear idea of the means employed. The specifications provide that "The system of final disposal shall be thorough sterilization of all material by means of live steam at a temperature not less than 282° F., the material to be subjected to this temperature in a closed vessel absolutely steam tight, at a working pressure of not less than 60 pounds per square inch for not less than eight hours. From the time the material is delivered into the said vessel it shall not be exposed to the open air until after it has been pressed so that the solid part of the material shall contain moisture not exceeding 55 per cent., after which it may be finally disposed of by cremation, acidulation, or reduction for use as a fertilizing material.

"Four of the digestors constitute what is known as a battery, and each battery is connected with a pressing machine used for separating the liquids from the solids. From the presses the liquids flow through a trough into the grease-room, where, after cooling, the grease is skimmed off for use in soap and lubricating oil manufacture, while the rest of the liquid is evaporated under vacuum. After this evaporation it is known as 'stick,' and is mixed with the dried tankage (the solid matter) to form a fertilizing base. The tankage is carried from the pressroom to another part of the plant, where it receives a further treatment with phosphate, and is converted into a good brand of fertilizer."

The beginning in reduction methods in this country was in Buffalo in 1887 by the introduction of the "Merz" process, of Vienna. This method was afterwards used in six other large American cities, but abandoned in all except one (St. Louis) for various reasons.

The Arnold process, which came into use in New York, Philadelphia, Boston and Brooklyn, is still employed in these cities.

The Chamberlain system is used in Detroit, Washington and Cincinnati; the Weislogel system, a modification of the Merz process, at Indianapolis; and the Holthaus system, after being tried at Bridgeport, New Bedford and Syracuse, is now in use in the latter city only.

At this date twenty-four cities are employing the reduction process, under five different methods, each differing slightly in the manner of treating the garbage.

In the last four years reduction plants dealing with garbage only, have been established in the cities of Washington, Baltimore, Newark and Cincinnati. These cities awarded contracts for a term of five years to the reduction companies upon the ground that these companies possessed the requisite capital to construct large, expensive disposal plants, and to carry them on with the expectation that the revenue to be derived from this work, together with the payment of a bonus by the city, would warrant them in undertaking a contract of great magnitude.

In order to get possession of these contracts the reduction companies were forced to compete with the local contractors in making the collection of garbage, and they were therefore obliged to put into this collection-contract a large sum of money for the purchase of a plant and the maintenance of a force of men and teams which would take the garbage from the houses of the people and bring it to the works.

Because of the unsanitary conditions and the nuisance connected with the disposal of garbage by reduction, the works are forced into locations considerably removed from the city proper, entailing thereby great expense in the transportation of the garbage, which expense is borne by the city.

In one case, where the reduction works were situated about a mile from a residential part of the city, the offensive odors and fumes became so annoying and so menacing to health, that the city was compelled to order the removal of the works, and was obliged to pay \$140,000 to have it done, because the reduction company adroitly claimed and proved that it was there by direction of the city and was therefore not responsible.

Another reduction company having a plant in operation were the highest bidders for a contract. They were underbid \$110,000 a year by a rival corporation, and when the contract was awarded to the lowest bidder it was found that as a limited time was stipulated for the construction of the works—less than one month in which to erect the apparatus and buildings that would have taken more than six months to build—the contract was necessarily abandoned by the lowest bidder, and was thereupon handed over, at their own figures, to the reduction company which had possession of plants ready to operate.

In another city the contract was let for five years, and practically no bidders were allowed to compete who did not have works of the largest capacity ready for immediate operation. It is hardly necessary to say that the contract went to the only bidder at an advance of nearly four times the previous price.

The foregoing shows that a reduction company with works already operating can simply hold a city at its mercy, can defy competition by adroitly shortening the time which would be necessary for the construction of an opposing plant, thus obtaining their own price with little, if any, chance given for successful competition.

So it has come about that in their garbage disposal work the largest cities of the country are in the hands of a monopoly composed of a number of corporations bound together by a common purpose, dividing the territory and mutually supporting, not opposing, each other, and putting it out of the power of any other company to compete successfully.

It has been stated by parties who are very well posted on the products of reduction, that the grease and tankage recovered by the treatment of garbage are of value more than sufficient to pay all the expenses of the work and leave a very good margin of profit, even if the city did not contribute one cent to the support of the company. It is known that 3 to 4 per cent. of grease can be recovered from the average ton of garbage, and that there is a certain amount of residuum, about 20 to 30 per cent., coming from vege-

table matter or the tankage left after the drying and steaming processes, which has some value as a filler for fertilizer. To these may now be added a third element of profit in the shape of a residuum to be derived from the evaporation or distillation of the water discharged from the garbage in the process of cooking by reduction. The constituent obtained (ammonia) is the most valuable of all the items that enter into the manufacture of fertilizer, and it is understood that this can be saved by the process now in use in the most modern reduction plants. It may be accepted as a fact that the total value of the manufactured articles derived from the reduction of garbage represents not less than \$2.50 for every ton of 2,000 pounds of average city waste treated in this manner. The expenses attending the recovery are large, but the balance of profit is sufficient to afford a very good return for the money invested.

Within the last two months an incident has occurred in the matter of disposal of garbage by reduction which, if it proves successful, will cause a revolution in the future of this work. A Western city advertised for bids for the disposal of the garbage, dead animals and nightsoil of the city, the work to be done by approved methods within city limits, or within an area of three miles, the city to collect and deliver all the waste. A proposal was received and accepted from a responsible company, backed by the required bond, to take all three forms of waste, free of expense to the city, and treat them after the company's own methods, without nuisance. This company will derive its revenue solely from the manufactured products of the waste.

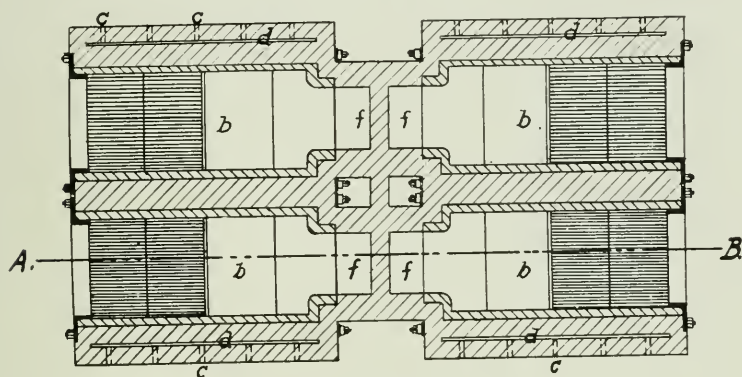
If this process be practical—and a year will demonstrate this—then there may be a new factor to be reckoned with in the disposal of garbage by the reduction process.

DESTRUCTION BY FIRE.

There are two remaining methods for the treatment of municipal waste to be considered: first, cremation in closed furnaces, and the utilization for steam power of the heat thus produced; and second, the utilization of such parts of the refuse as may be sold for conversion of manufacture into

other forms of usefulness, and the disposal of the worthless residuum.

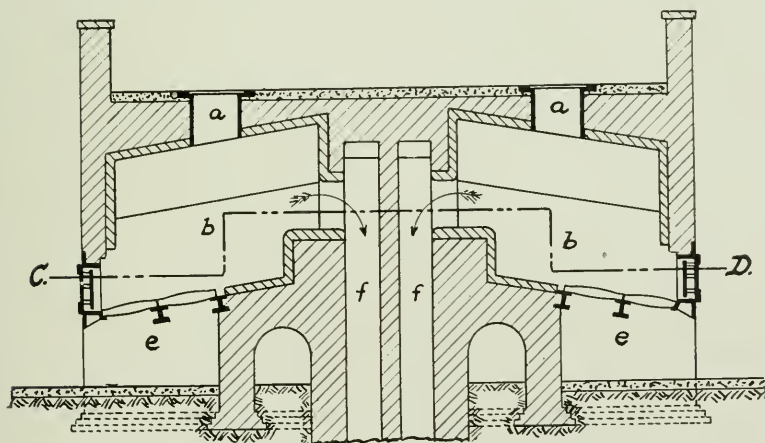
The destruction of waste by fire is as old as civilization



PLAN ON C. D.

FIG. 1.—The first English destructor, Manchester. Plan.

itself, but the process of burning in furnaces, as now practised, originated in England something like a quarter of a



SECTIONAL ELEVATION ON A. B.

FIG. 1a.—The original Manchester furnace. Section.

century ago, and has been continuously improved upon since that time up to the present day. About 1870, the sanitary conditions in many English towns became intoler-

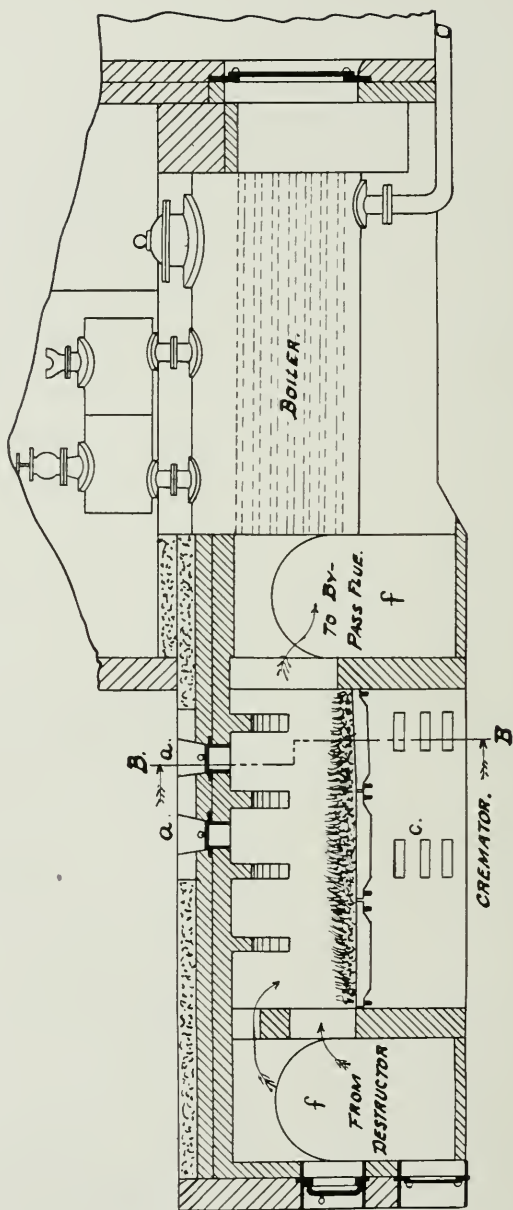


FIG. 2.—The Fryer destructor, 1876-77, and Jones fume cremator, 1883-84.

able owing to the accumulations of waste and refuse which for centuries had been dumped within the town limits, or upon the borders of the communities. A rapid and sani-

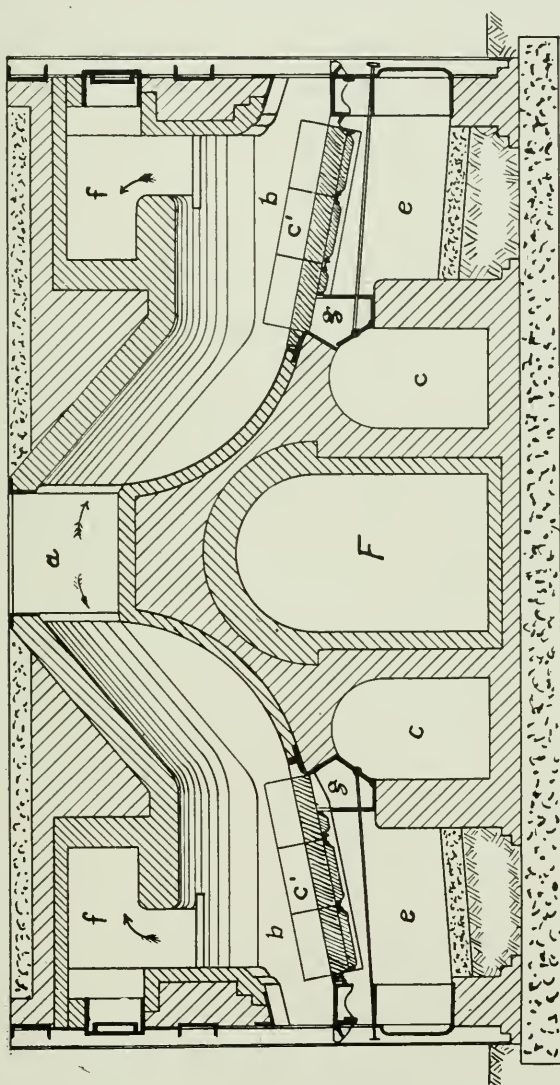


FIG. 3.—Horsfall destructor, 1888.

tary method of disposal was sought, and the first attempt at destruction by fire was made at Paddington, a suburb of London, by the erection of a crematory built by the

Messrs. Mead, dust contractors. This attempt was only partially successful, as the furnace operated badly by natural draft, and no provision was made for the prevention of the emission of odors and fumes resulting from combustion.

In 1874-5 a furnace which was afterward called a "destructor" was built at Manchester. In 1876, the construction of this Manchester furnace was imitated by Fryer, at Ealing, and the type continued at Birmingham, Leeds and Bradford, all of which cities installed destructors during the three following years.

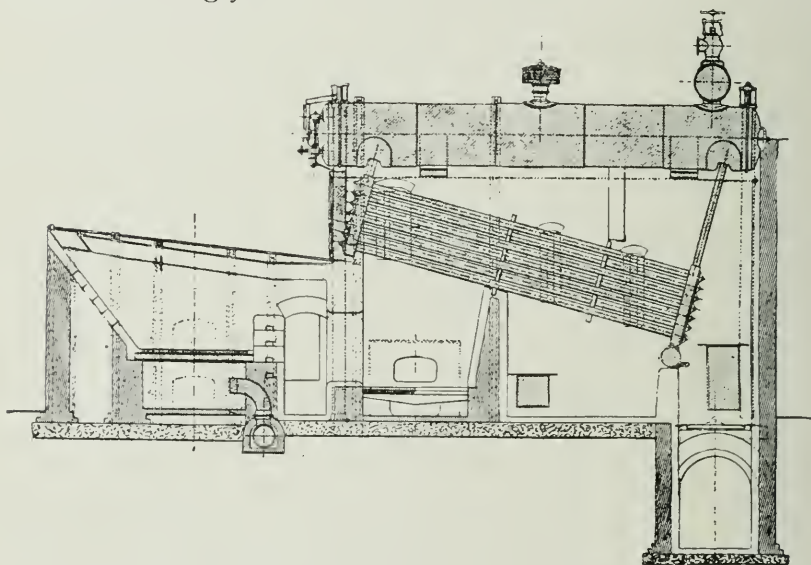


FIG. 4.—Beaman & Deas destructor, with boiler, 1893.

The weak point of the *Fryer Destructor* was that no provision was made for the destruction of the fumes. An improvement in this respect was made by Jones, of Ealing, who introduced a "fume cremator," consisting of a secondary fire situated in the flue leading from the destructor to the chimney. This was the first attempt made to render the operation of the furnace sanitary.

The next improvement was made by *Horsfall*, in 1887-88. The same type of construction was preserved, and the improvement consisted of a forced draft over and under the fire-bars, thus increasing the temperature and permitting

the introduction and use of a water-tube boiler in close proximity to the destructor; the arrangement of the flues and flue openings, and a new variety of fire-bars.

There were subsequently brought into use several other forms of destructors, which upon trial were found to be efficient and in many respects entirely sanitary, but which, for one reason or another, failed to reach popular favor. Among these were Healey's Destructor, the "Acme" Destructor of Messrs. Hart & Royle, Warner's "Perfectus," Mason's



FIG. 5.—Beaman & Deas destructor, Darwin, England.

"Gasifier," and the combined Destructor of Messrs. Goddard, Massey & Warner.

The Beaman & Deas Destructor, which was brought out in 1893, was of the same type as its predecessors, a twin cell furnace connected with a water-tube boiler, and having forced draft under the ash-pits which raised the temperature to the highest degree yet attained and insured perfect combustion of the gases and the utmost power and efficiency. All these destructors, together with others not mentioned,

were of the characteristic English cell type, depending upon the alternate charging of each cell for the combustion of the gases and the utilization of the heat for the operation of the steam boiler.

In 1898 appeared an entirely different form of destructor called the "*Simplex*," invented and built by the Messrs. Meldrum Bros., Ltd., of Manchester.

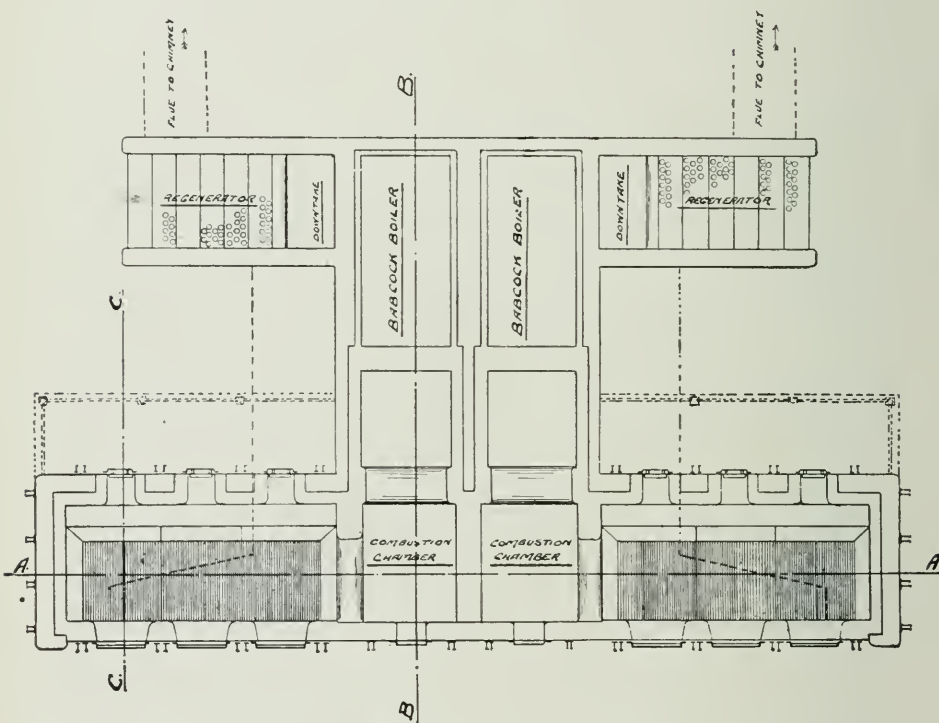


FIG. 6.—Plan of two three-grate Meldrum "*Simplex*" destructors, boilers, etc., 1898.

This destructor is a furnace of the modern type, and as compared with others is wholly original and novel in arrangement. It combines efficient, inoffensive cremation of refuse with the production of a maximum amount of steam power.

The furnace is practically one long cell, fed and clinkered through two, three or four separate openings, according to the number of grates installed.

The grates are arranged side by side, separated by dead-plates. The ash pit is divided into sections corresponding with the grates above, and each section is closed by air-tight doors. In this closed section of ash-pit, beneath the grate, are placed patent steam blowers, which deliver any desired pressure of forced draft up to 6 inches of water column, the average blast used being $\frac{1}{8}$ inch of water.

The charging of this destructor is done by hand-feeding through the fire-doors, or through charging-holes on the top of the furnace. The several grates are charged and clinkered in rotation; the gases and smoke from any one of the

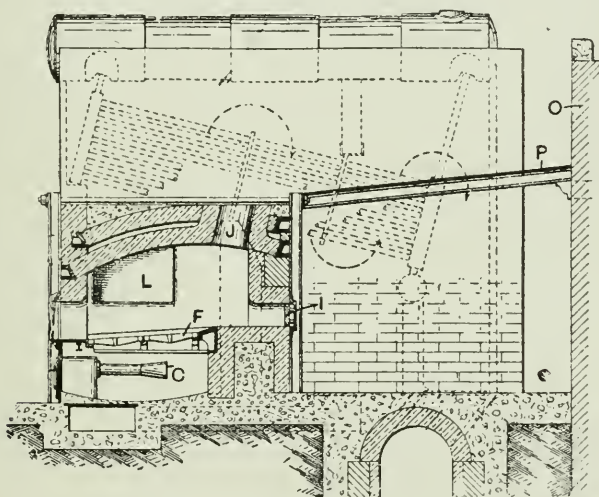


FIG. 7.—Cross section, Meldrum "Simplex" destructor.

freshly-charged grates are rendered innocuous by the action of the others, which remain at high temperature. If grate No. 1 be charged in small quantities, immediate ignition of the material is secured and the gases as distilled in their sideway motion must pass over and intermingle with the heated volume passing from Nos. 2, 3 and 4, the whole volume then entering the combustion chamber. This combustion chamber has a temperature of 1,800° to 2,700° F., which insures the perfect combustion of the vapors and products of cremation. After passing through the boiler, the hot gases are utilized in heating the air forced under the

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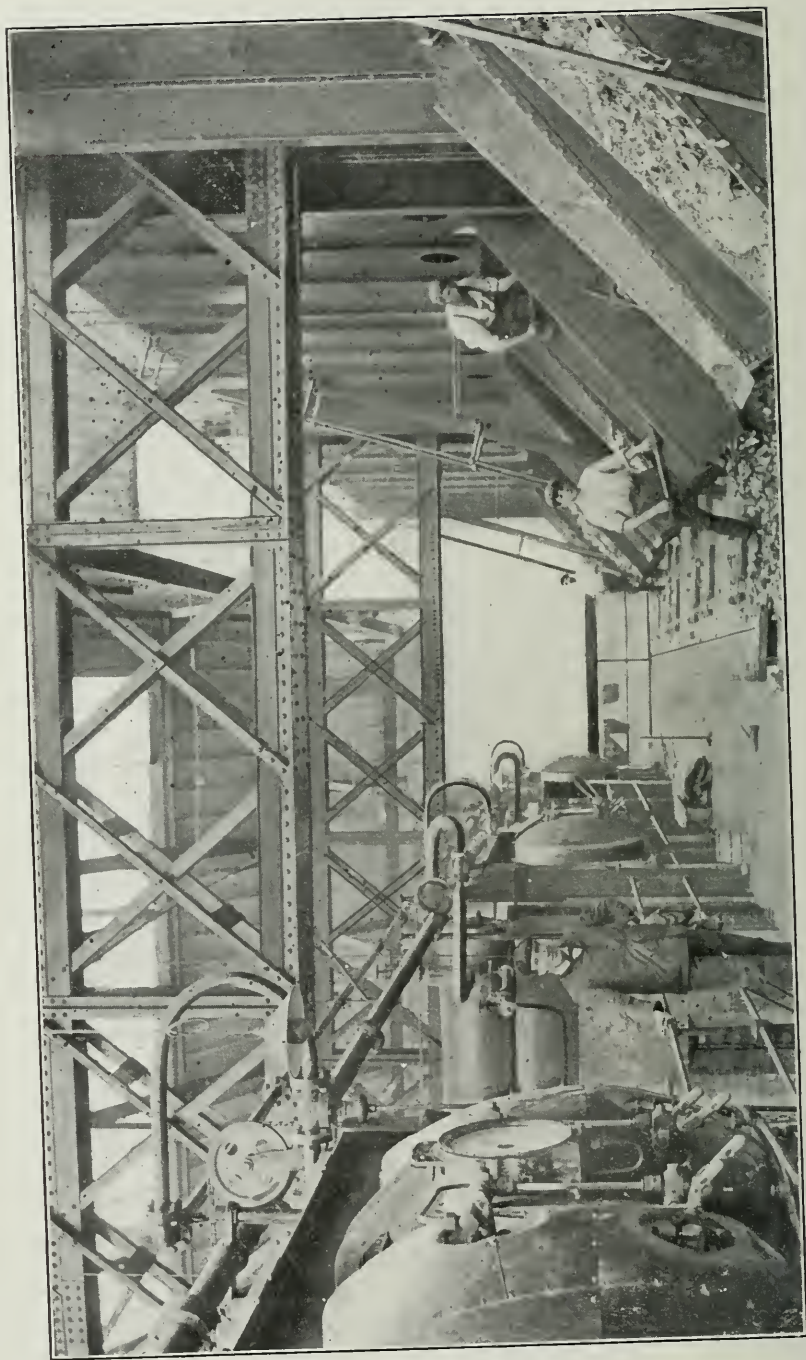


FIG. 8.—Charging platform, destructor, Hackney, England.



FIG. 9.—Front of destructors, Hackney, England.

grates by means of an economizer or regenerative air heater, placed in the flue beyond the boiler. The temperature of this air, raised to 300° F., and supplied under the grates at a pressure of $1\frac{5}{10}$ inches water column, insures the rapid evaporation of all liquids and is a most important factor in the destruction of all combustible matter, the production and maintenance of the highest obtainable temperature, and the development of the greatest amount of steam power.

One of the main advantages of the Meldrum Destructor is its economy, for the large amount of heat developed may be attained by the use of the poorest kind of fuel—coal or coke dust, ash-pit refuse, ashes, anything, in fact, possessing calorific value.

LATE IMPROVEMENTS IN DESTRUCTORS.

The really vital improvement, the cause of the rapid progress made in Great Britain in the last few years is the high temperature attained by the introduction of powerful currents of steam or heated air under the ash-pits of the furnace. In the old forms the temperature of the gases rarely reached more than 1,000 degrees, and it took nearly seventeen years of progressive work to bring the temperature to a point where complete combustion was attained without the emission of fumes and odors. In 1887 the temperatures ranged from 500 degrees to 750 degrees. In 1902, at Walker-on-Tyne, the temperature of 3,000 degrees was attained by a Meldrum Destructor.

The second important improvement in English practice was the use of steam boilers of large capacity in direct connection with the destructor, which utilized all the heat generated. A report of the examinations made by Lord Kelvin and Sir Douglas Fox (1896-7) shows that the Horsfall and Beaman & Deas Destructors evaporated from 1 to $1\frac{1}{4}$ pounds of water for every pound of waste consumed. The latest reports from Meldrum Destructors operating at Nelson, England, show that in 1892 1.95 pounds of water were evaporated for each pound of mixed town's refuse consumed.

The steam power thus developed, a valuable element of economy in the management of municipal affairs, has been

widely utilized by the cities and towns of Great Britain during the past five years. It has been applied as auxiliary in the production of electrical power in no less than sixty-three cities; and this power has been utilized in connection with the sewage-pumping works in about forty towns. In several instances the water supply of a town has been pumped by the aid of the power derived from the incineration of the town's refuse. To sum up, of the one hundred and eighty places in Great Britain where destructor plants are installed, over one hundred of them are combined with the electricity or sewage works.

There are no reasons why the best forms of English destructors are not adapted to the conditions of disposal work in this country. It is true that English municipal waste contains a larger proportion of ashes, clinkers and cinders, a smaller proportion of garbage containing moisture, and a less amount of combustible refuse, or rubbish, than American city waste, but, on the other hand, American municipal waste, although it contains a larger proportion of garbage, which carries a higher percentage of moisture than the English, has an ash collection which contains from 17 to 25 per cent. of unburned coal, and has also a refuse, or rubbish, collection which is three times as great as that of the English towns.

Taking the average percentage of each, and calculating the calorific value of the waste of American cities as compared to that of the waste of English towns, there is no reason to doubt that the destruction of our waste in furnaces of the English type may be achieved successfully without the use of fuel, the heat values being made up in one direction when they are lacking in another owing to the variance in the nature of the waste.

In illustration of the operation of English destructor plants consuming unseparated municipal waste the following reports, covering a period of three years, taken from three separate installations, will be found of interest:

DARWEN REFUSE DESTRUCTOR.

Duration of test, 48 hours continuous.

State of weather: very heavy showers—rainfall .92 inch on Friday, and .16 inch on Saturday.

Total quantity of refuse destroyed	63.88 tons.
Description of refuse: unscreened ash pit refuse, 61.88 tons; slaughter-house and fish-market offal, 2 tons; the average percentage of moisture being 35 throughout the refuse.	
Total weight of clinker remaining	19½ tons = 30.6 per cent.
Temperature of feed water (average)	185° F.
Water evaporated per pound of refuse (actual)	1.48 pounds.
Water evaporated per pound of refuse (from and at 212°)	1.55 pounds.
Average steam pressure per square inch	183 pounds.
Average temperature of combustion chamber	1,633° F.
Highest temperature of combustion chamber, over	2,000° F.
(Copper melted five times.)	
Lowest temperature of combustion chamber	1,201° F.
Average temperature of flue after leaving boilers	703° F.
Average temperature of flue after leaving regenerator, ...	585° F.
Average temperature of feed air from regenerator	328° F.

Extract from figures of test made at Nelson, December 20, 1900.

Duration of test	9½ hours.
Grate area of cells	100 sq. feet.
Heating surface of boiler, one Lanc. type, 30 x 8 feet	986 "
Refuse consumed per hour	5,703 pounds.
" " " square feet of grate per hour	57 "
Water evaporated per hour from and at 212° F.	8,650 "
" " " pound of refuse from and at 212° F.	1.516 "
Average percentage of CO ₂	12.21 per cent.
" temperature of combustion chamber	2,200° F.
Percentage of clinker	21.18 per cent.
NOTE.—The boiler was not clothed when this test was made.	

Extract from figures of test made at Nelson, April 25, 1901.

Duration of test	8 hours.
Refuse burned per hour	6,853 pounds.
" " " square feet of grate per hour	68½ "
Water evaporated per hour, from and at 212° F.	13,442 "
" " " pound of refuse from and at 212° F.	1.96 "
Water evaporated per square feet of heating surface from and at 212° F.	13.6 "
Average percentage of CO ₂	14.40 per cent.
" temperature of combustion chamber	2,227° F.
Percentage of clinker	29.06 per cent.
NOTE.—The boiler was covered with non-conducting composition.	

Extract from figures of test made at Lancaster, February 7, 1902.

Duration of test	12 hours 26 minutes.
Grate area of cells	100 sq. feet.

Type and size of boiler	Lancashire, 30 x 8 feet.
Water evaporated per hour from and at 212° F.	9,820 pounds.
Water evaporated per pound of refuse from and at 212° F.	1.63 “
Average percentage of CO ₂ in flue gases . .	15.50 per cent.
Average temperature of combustion chamber, (Copper could always be melted.)	Over 2,000°
Average temperature of heated air from re- generator	478° F.

WOOD PULP POLLUTION OF STREAMS.

The United States Geological Survey renewed, at the beginning of the Bowdoin College year, arrangements with Prof. Franklin C. Robinson for further co-operative work. The task set for Professor Robinson under the existing agreement will be somewhat different from that formerly performed by him. Under the previous agreement Professor Robinson took water samples from the Androscoggin River above and below Rumford Falls, Livermore Falls, and Lewiston, and above Brunswick, and on Penobscot River above and below Bangor. This arrangement resulted in the collection of results in twenty-five analyses, nineteen on the Androscoggin and six on the Penobscot. They show, in a satisfactory manner, the character of the water in these rivers during the summer and winter seasons, but give no conception of the effect of the extensive pulp pollution during dry summer seasons. The work which it is now proposed to undertake will be directed toward a definite determination of the effect of wood-pulp wastes upon natural waters. The problem is a broad one, and is receiving considerable attention in those parts of the United States where pulp mills have been located, and it is obtaining especially prominent notice in the vicinity of Lake Champlain. The plans made contemplate a precise determination of the character of sulphite and soda-pulp wastes and their stability. It is important to know whether this waste is of itself highly putrescible, or whether it has characteristics similar to those of straw-board waste, being stable itself, but affording abundant opportunity for the decomposition of matters brought into contact with it.

When the nature of the pulp waste has been determined, experiments will be made for the purpose of showing how it persists in its effects as it is diluted and carried down stream. Already the facts which have been gathered with reference to this point have proved interesting, notably one in connection with the effect of waters polluted with pulp-mill wastes upon aniline dyes. A complaint was received some time since from an official of a woolen mill in the city of Lewiston, which stated that, if Androscoggin River water were used for washing materials that had been dyed with aniline dyes, the color of the goods was destroyed and considerable loss was thereby sustained. It was stated that all colors that had been used in the dye-house were equally affected, and that all, after washing, had a reddish cast.

The investigation of the pulp pollution, with the investigation of straw-board waste, will furnish a valuable set of data concerning the whole subject of paper and board manufacture.

THE "TECHNOLEXICON" OF THE SOCIETY OF GERMAN ENGINEERS.

The Editor-in-Chief, Dr. Hubert Jansen, gives the following short report on the work done up to February, 1904: The universal technical dictionary for translation purposes, in English, German and French, the compilation of which was begun in 1901 under the auspices of the Society of German Engineers, has received help up to the present time from 353 technical societies at home and abroad; 51 of these are English, American, South African, etc., 274 German, Austrian, and German-Swiss, and 38 French, Belgian, and French-Swiss societies. Of firms and individual collaborators 2,573 have promised contributions.

The excerption of texts in one, two or three languages (handbooks, pamphlets, business-letters, catalogues, price-lists, etc.) and of the existing dictionaries has yielded 1,920,000 word-cards so far. To these will be added within the next two years (by the middle of 1906) the hundred thousands of word-cards that will form the result of the original contributions—those already sent in and those still expected—of the 2,573 collaborators at home and abroad, when the editors in Berlin have finished them for the press. Specially made handy note-books had been placed at the disposal of the collaborators to write their collections in, of which 317 have come in filled so far.

The outstanding contributions were called in by Easter of this year, 1904, unless a later term had been especially arranged with the Editor-in-Chief. As the printing of the "Technolexicon" is to begin in the middle of 1906, delayed contributions will continue to be received and utilized as far as possible.

The Editor-in-Chief will be pleased to give any further information wanted. Address: "Technolexicon," Dr. Hubert Jansen, Berlin (NW. 7), Dorotheenstrasse 49.

PETROLEUM BRIQUETTES FOR FUEL.

A new process of manufacturing petroleum briquettes has been invented by M. Maestracchi, so Mr. Oliver J. D. Hughes, the United States consul-general at Coburg, reports. The process is a simple one, consisting of mixing petroleum with three other chemicals in the following proportions: Petroleum, 1 liter; soft soap, 150 grains; resin, 150 grains; caustic soda lye wash, 300 grains. This mixture is then heated and well shaken, after which it is allowed to solidify. This operation occupies about forty minutes. Care has to be observed to prevent the liquid running over, and this is achieved by pouring a small quantity of soda into the vessel and shaking it well until solidification is completed. The mixture is then run into briquette molds of the requisite size, and these are then submitted to a furnace heat for ten or fifteen minutes. The briquettes are then set aside to cool, which occupies an hour or two, and then they are ready for use. If it is desired to make the briquettes more solid, this can be accomplished by the addition of sawdust or sand to the mixture. Experiments have demonstrated that these briquettes yield three times as much heat as ordinary coal; they are lighter in bulk and easier to carry; and what is more important, after consumption, there is very little ash or other residue.

Mechanical and Engineering Section.

Stated Meeting, held Thursday, October 22, 1903.

Modern Expanding and Flanging Machinery and Tools.

BY LUTHER D. LOVEKIN,

Chief Engineer, New York Shipbuilding Company, Camden, N. J.

In presenting this subject before the Institute this evening, it is my intention to describe the machinery, tools and methods of operation as fully as possible, so as to enable my hearers to see for themselves the many advantages possessed by them, both in regard to labor saving and the wear and tear incident to such machines and tools.

Attention was first called to the writer on the subject during the year 1889, while employed with one of the largest shipbuilding establishments in the United States.

Noticing the great amount of labor in placing the flanges on copper pipe, I decided to make an experiment in order to place on the market a new type of joint which I had previously invented (of a much cheaper manufacture, if successful). This, however, could not be done, owing to existing laws in the United States inspection service, so I turned my attention to the making of joints already in use.

My first experiments were with 8-inch copper pipe. In order to avoid excessive expense I used a large lathe we had in the shop, and revolved the pipe, the roller being held in tool post on a suitable arm. This method proved most satisfactory, and convinced me that it was time to work in this direction if one wanted to see the copper shop running on an economical basis, similar to other shops.

There was one thing that struck me most forcibly, and that was the lack of any improved machinery in our copper shop; I presume the idea being that no improvements were needed. Seeing this state of affairs I decided that it was the best field that I could cultivate, and, accordingly, I designed the experimental machine shown in *Figs. 1 and 1a*.

With this small hand-crank machine I turned out the first sample of a new departure in the coppersmith's art—

of rolling the pipe into the flange and beading it over; in other words, I perfected the joint in the machine to such an extent as to place it beyond any possible criticism.

The next test I made was that of tightness. Prior to my

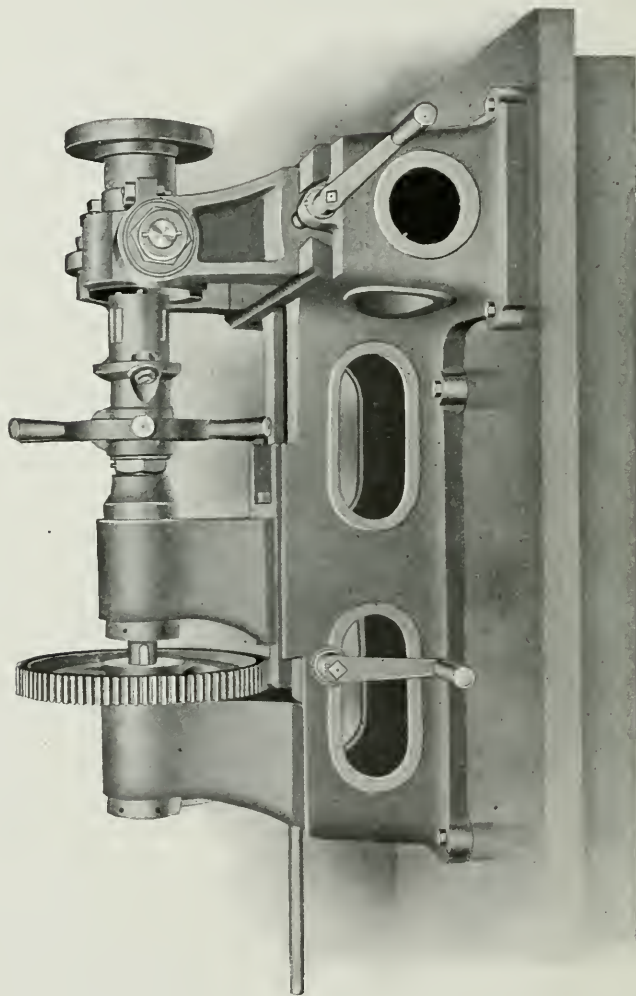


FIG. 1.—Experimental expanding machine (side view).

machine-made joint it was impossible to secure a tight joint without resorting to brazing the flange on the pipe, a method which has proven for years past to be most destructive to the copper, and which has been the cause of many

failures in copper steam pipes, resulting in considerable loss of life. So I had a few samples made and tested according to my idea, with the result that in every case the

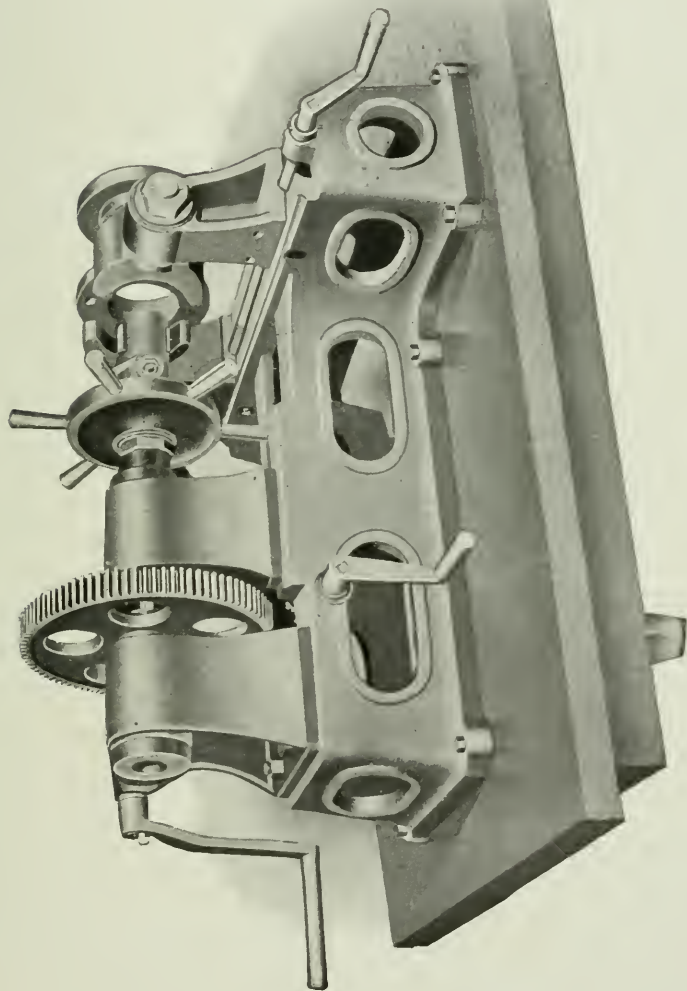


FIG. 1a.—Experimental expanding machine (side view).

pipe would rupture in the middle (as shown in *Fig. 2*, due to the copper having reached its limit of tensile strength) without showing any signs of leakage up to a

pressure of from 1,500 to 2,000 pounds. The pipe tested was 4 inches in diameter and $\frac{1}{8}$ inch thick, and by formula

$$\frac{P \times D}{2 - T}$$

we found the copper good for a tensile strength of

$$\frac{2000 \times 4}{.25} = 32,000 \text{ pounds,}$$

which is about what we expected. *Fig. 2a* shows method of flanging the above-mentioned pipe in section.

A similar pipe was then tested, this pipe having been put in the flange by means of peneing, or, as we will call it, the "old method;" *Fig. 2a* also answers for this illustra-

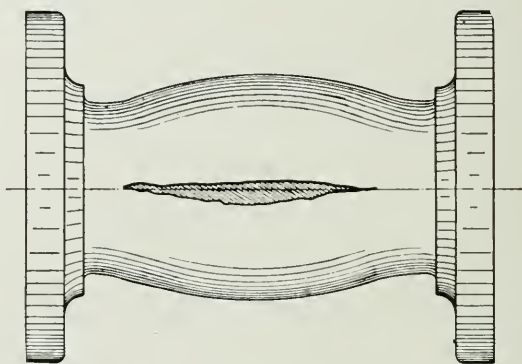


FIG. 2.

tion, the flange being bored out similar in each case, and then in addition this pipe was brazed to the flange. This pipe stood the test up to 1,200 pounds and then began leaking back of the pipe around brazing.

It is worthy of mention to note that with this hand-crank machine the flange was rolled in completely in ten minutes, while it took two hours to hammer the other sample in, without mentioning the fact that no comparison could be made as to the appearance of the work, the sample made by the machine being perfectly smooth, uniform in thickness and no flaking; while the one hammered in showed hundreds of indentations from the ball-faced hammer used for such work, no uniformity in thickness and

considerable flaking, without mentioning the fact that the flange had become so distorted in hammering the pipe into same as to necessitate it being refaced. This latter trouble nearly always exists, especially so in high pressure work, and is the result of the continual battering with the hammer inside the pipe.

Thousands of dollars are expended annually owing to such crude methods being employed.

The following is a brief description of the present methods employed in most copper shops throughout the country, together with a comparison of the work necessary when using the machine and tools:

In order to connect the flange and pipe at the present

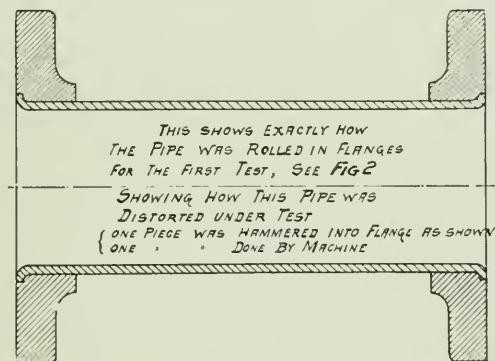


FIG. 2a.

time, flanges are made and *turned on the face and bored*, after which the copper pipe is entered into the same and hammered by hand, so much as to distort the flange in almost every case. This, however, does not form a tight joint, and in order to prevent leaking of same, brazing has to be resorted to, which, as is a well-known fact, materially decreases the strength of the pipe, inasmuch as it destroys the properties of the copper and also warps and twists the flanges, due to their being heated.

After this is finished, another expense is added. The pipe is then taken to the machine shop and placed on a boring and facing machine, to be faced up, and the amount of time necessary to reface this flange complete depends

entirely on the shape of the pipe and the size of same, a 4 inch pipe requiring anywhere from one to two hours to complete said work. This amounts to several thousand dollars a year, and when finished it will not begin to compare with that done by the machine.

With the machine-made joint the flange is bored and faced, placed in the machine, pipe entered and clamped, and the operation completed in about ten minutes for a 4-inch pipe, the expanding, as well as the flaring, being perfect; and inasmuch as we can see the effect of the tool marks on the copper, we know the danger of leaking is no more than that of a boiler tube where we resort to expanding alone.

I believe the law compelling the brazing of pipes was originated on account of the impossibility of securing tight joints with high pressure, leakage occurring between pipe and flange on the outside; but with tests which we have conducted with our machine-made joint, brazing is not necessary. There is no comparison as to neatness, efficiency and cost of production, and if brazing is required it can be done very readily from the back of the flange, without destroying the face.

I will now describe the new list of machines and tools which are being placed on the market to do this class of work in the most approved manner, with a saving that will startle the proprietors of all such establishments where these old methods prevail.

The machines and tools were designed to meet the demands of shipbuilders and engineers generally, where a large amount of wrought iron, steel and copper piping is required to be expanded tightly in the flange as well as beaded over the same, thus dispensing with the common practice of screwing or peneing by hammer flanges on pipe, especially so when such pipes are subjected to the action of salt water or to any vibration.

It is well known that there is considerable wrought iron used in connection with the bilge and ballast system, sounding tubes and air pipes of vessels, all of which have given considerable trouble due to using the threaded pipe.

These machines and tools, illustrated, were designed with

a view of doing work of such a character as to avoid these troubles. When we consider that the piping throughout ballast tanks is usually made of wrought iron for salt water, and has a thread cut on same to receive the flange, it is evident that the life of a pipe is simply a matter of short duration, as it will corrode at the bottom of the thread first, and is a continuous source of trouble; while with our method the thickness of the pipe remains uniform throughout, and can therefore be a much lighter gauge for the same lasting qualities. Again, the immense extra weight of piping carried on ships or even in our large buildings, which becomes necessary when screwed piping is used in order to get the proper thickness at the bottom of the thread, is fully 20 per cent. more than necessary for the same lasting qualities.

THE LOVEKIN EXPANDING AND FLANGING MACHINE FOR
PIPES, 2 INCHES TO $7\frac{1}{2}$ INCHES INCLUSIVE—CLASS "A" SIZE.

The above-mentioned machine consists of a cast-iron base (as shown in *Figs. 3 and 3a*), having at the rear end a motor for driving the same, or it can be driven from countershaft overhead. The motor drives the machine by means of a belt to the cone pulleys (as shown), so as to permit of variable speeds being used, or by means of countershaft overhead provided with cone pulleys, in case the motor is not desired.

This shaft on the machine is provided with a worm which engages in a worm wheel, suitably housed on the rear end of the machine. The worm wheel has a long sleeve cast on the same, and is also provided with a round collar or nut at the extreme end of this sleeve. The worm wheel and its sleeve are free to revolve; the inner bore of this sleeve is provided with a key-way, so as to allow the central or driven shaft to move freely forward and backward as desired, and the feather transmits the power to the central or driven shaft, causing it to revolve.

This worm and worm wheel, together with their brackets, all form a fixed part of the machine, with relation to the driving mechanism. The central shaft passes through

the worm wheel and is made to form a socket for all sizes of tools at the forward or front end of the same. This man-

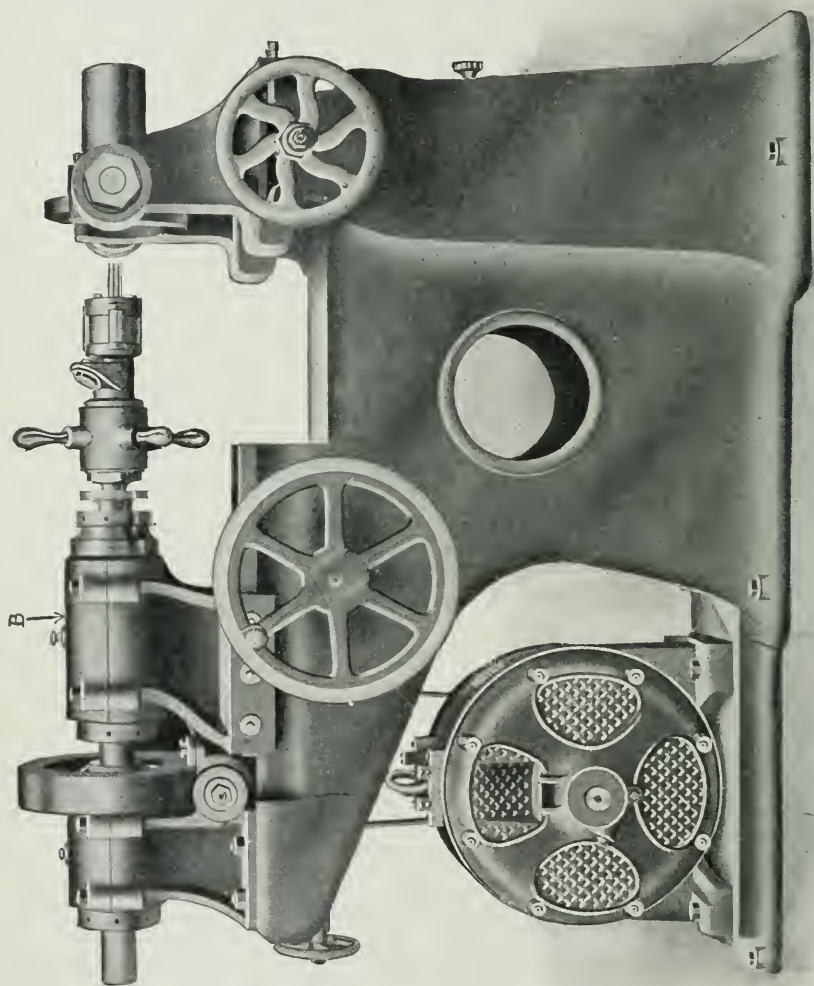


FIG. 3.—The Lovekin expanding and flanging machine (side view).

drel is provided with collars, and thrust or anti-friction rings at the front end, and a round nut at the rear end of

movable bracket *B*, as shown in cut, *Fig. 3*. This enables the shaft to revolve freely in this movable bearing, but it

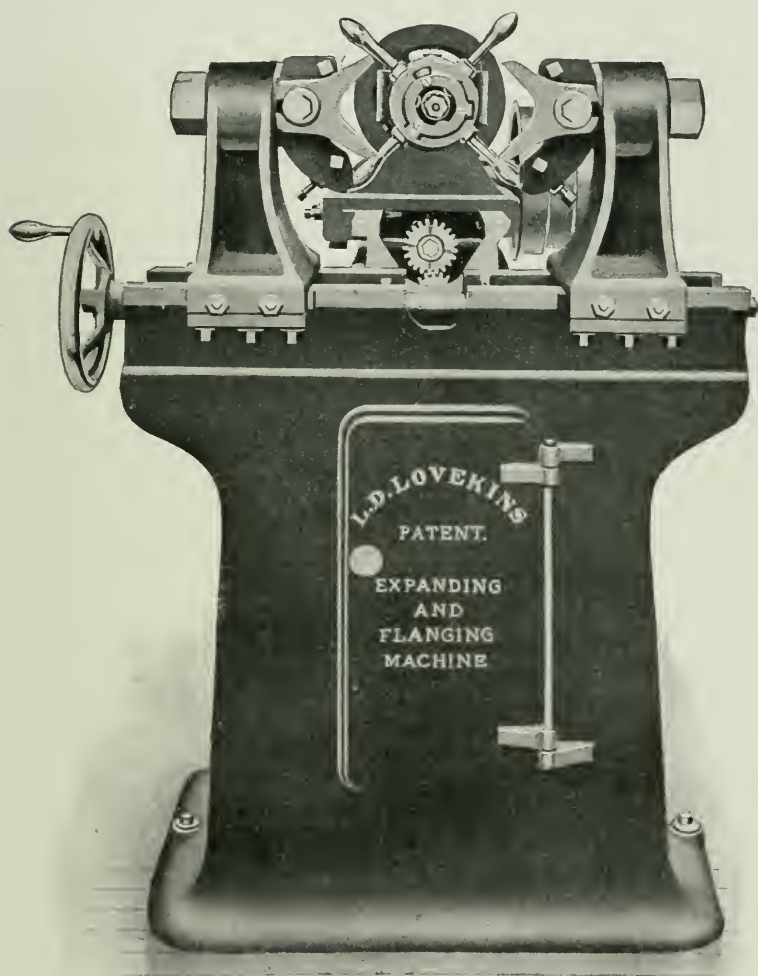


FIG. 3a.—The Lovekin expanding and flanging machine (side view).

cannot move unless bracket *B* is advanced. This bracket *B* is made with adjustable guides at the sides, and is also

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provided with a nut underneath, through which passes a lead screw. The lead screw is provided with bevel wheels of suitable size, and located to suit the best position of the operator in charge.

The lead screw is used to move the head *B* to and from the work to be operated on as desired, the head *B* having the shaft held in same that forms the socket for all tools. Thus it will be seen that all the forward and rearward movement necessary for the various sizes of pipe is obtained by means of this sliding bracket *B*. In addition, the central shaft revolves in this bracket; and to provide for the end thrust on this bracket the lower edges are provided with good and substantial guide strips, thus preventing any tendency to lift up, due to this end thrust.

The central shaft is provided with large head at the front end, so as to form a large surface for anti-friction collars placed between the bracket and the shoulder on center shaft, thus reducing the friction to a minimum.

The front portion of machine, as shown in *Fig. 3a*, consists of two sliding heads mounted on suitable guide-ways on the base of the machine. These heads have a right- and left-hand screw, passing through nuts on the underside of the same, and causing said heads to move from each other at equal distances from the center. The heads are made of cast iron, and are fitted with detachable clamping jaws of cast iron. These jaws are also provided with tool steel "V" grips, for holding the pipe centrally and preventing from turning while being expanded.

The cast-iron jaws are made with grooves of suitable size, to permit the flange being held in the same, independent of the pipe. These grooves are faced on the rear side, so as to be in perfect alignment with the central shaft. This permits the flange being placed exactly in line as desired; and at the back ends suitable set screws are located, so as to force the faced portion of the flange against the faced portion of the jaws. The backs of flange being rough castings, and at times having bosses on the back, make this method of securing the best possible after years' experimenting.

The machine is also provided with suitable locker and shelves at the front end. These will be found useful for stowing small parts.

(To be continued.)

STORING COAL UNDER WATER.

In connection with the experiments of the British Admiralty on the storage of coal under water for the purpose of retaining the calorific value of the fuel, some interesting information upon this subject has been vouchsafed by Mr. J. Macaulay, the general manager of the Alexandra Docks and Railroad of Newport. He recovered a quantity of coal that was known to have been submerged in the docks under his control for periods varying from three to ten years, and also further quantities from the estuary of the River Usk, whither the fuel had been carried by currents and tides from wrecks in the Bristol Channel. The latter coal was considered to have been for more than two years under water. This coal was experimented with upon the locomotives employed at the docks in competition with the best freshly mined coal obtainable. The trials were carried out under similar conditions so that absolutely comparative data might be obtained. The results showed that the first place was taken by the river-submerged coal, followed by that which had lain submerged in the docks for ten years, with the newly mined coal third. According to this expert, coal loses about 10 per cent. of its steam-generating power when stored in the open air for any great length of time, the greater part of this deterioration taking place during the first year. From these tests it is apparent that the best method of storing coal with a high calorific value is under water, if it is to be stored for any great period. Subaqueous storage is cheap, and has the further two important advantages, of immunity from hostile attack, and ready access when required, and it permits the utilization of a great space for other purposes that would otherwise be occupied by the bunkers of coal on land.—*Engineering and Mining Journal*.

OBTAINING METAL POWDERS BY AN ELECTROLYTICAL METHOD.

Prof. A. Zamboni (*Elettricità* No. 4, 1903) has succeeded in obtaining aluminum, sodium, potassium, etc., amalgams, decomposable in water. His method is based on the fact that when electrolyzing a solution of metallic compounds by means of a mercury cathode, the corresponding amalgam is obtained; this process may be applied even to such metals as are commonly regarded as unamalgamable, such as, for instance, platinum and iron. The amalgams thus obtained are spongy substances, filled with mercury particles, and have specific weights between those of mercury and the corresponding metal. By compressing in linen bags the amalgam thus economically obtained, nearly pure mercury will be obtained, the amalgam undergoing a partial decomposition, when a readily pulverized substance will remain, made up of amalgam and metallic powders. If this mass be distilled at a temperature below the melting point of the amalgam, the mercury is found to separate from the metal (especially in the case of iron and related metals), whereas the

latter remains in a spongy, friable state, being capable of reduction, when pounded, to extremely fine powder. When choosing for this distillation convenient atmospheres, different metallic compounds will be obtained. If, for instance, iron amalgam be distilled in a reducing medium, pyrophoric iron will be obtained, susceptible of being converted into common iron by a convenient treatment. Oxidizing atmospheres will give some so far unknown iron oxides and protoxides.

The above process was found in the course of an investigation of the Edison accumulator; it was originally intended to afford a ready means of preparing ferric oxide.—*Scientific American*.

NEW RAILWAY UP VESUVIUS.

Messrs. Thomas Cook & Son have just constructed a new electric railway up Vesuvius from Pugliano, the northern quarter of Resina, to the terminus of the old funicular railway, which was made up the cone to the crater twenty-three years ago. This new line is nearly $4\frac{3}{4}$ miles long. Except for a section in the middle, it is laid with a ruling gradient of one in $12\frac{1}{2}$, and the cars run by adhesion. In the middle portion the gradient rises to one in four, an incline as great as that of the Righi line, and in consequence it has been necessary to use a rack rail, the Strub system having been selected, as on the Jungfrau railway. On this rack-rail section the cars are pushed up by a four-wheel locomotive provided with two 80 horse-power motors, and fitted with an elaborate system of ordinary and emergency brakes. On the other sections the cars, which seat twenty-four passengers and can accommodate six more on the platforms, are propelled by their own motors, the current being supplied through overhead trolleys, as is also the case for the rack-line locomotives. The generating station stands at the foot of Monte Cateroni, close to the point where the rack-rail section begins. Pugliano is already connected with Naples by electric tramway, with the exception of a short length which has still to be finished, and the old funicular line up the cone has been reconstructed and equipped for electrical working; hence it will soon be possible to travel by electricity all the way from Naples to within 250 yards of the crater, a good deal more quickly and comfortably than is permitted by the present means of transport.—*Scientific American*.

NEW ENGLAND WATER POWERS.

New England water powers are being prospected with a good deal of system with the purpose of developing them for electric purposes. The possibilities contained in the rivers of these States are considered to be tremendous, in view of the rapid progress which long-distance transmission of electric power is making. Not a few New England manufacturers look to see the undeveloped and neglected water power of the section make up, to a considerable extent, for the distance from the coal mines, which is the chief disadvantage of manufacturing in the Northeastern States of the Union. In a country that is either mountainous or at least hilly in practically every section, reservoir sites may be found in plenty to provide against the times of low water, which is the chief drawback of the water power of New England as already developed.—*Iron Age*.

PHYSICAL SECTION.

Stated Meeting, held Thursday, December 17, 1903.

Osmotic Pressure.

BY GEORGE A. HOADLEY,
Member of the Institute.

About the middle of the eighteenth century Abbé Nollet demonstrated the existence of osmotic pressure by closing the lower end of a glass tube with a diaphragm of animal membrane, and, having placed alcohol in the tube, submerging the lower end in water, to such a depth that the hydrostatic pressure was the same without the tube as within it. This membrane prevented the passage of the alcohol through it, but allowed pure water to pass through freely, and only a short time was needed to demonstrate that the liquid within the tube was increasing in volume.

The same result is secured when an animal membrane separates a solution from its solvent. While investigating these phenomena in 1867, Traube devised a form of diaphragm called a semi-permeable membrane. This membrane consisted of an artificially prepared precipitate of copper ferrocyanide, the support being a vegetable parchment stretched over the end of a glass tube.

Though they had the property of permitting the solvent to pass through them freely, while the substance could not, these supports did not possess the rigidity necessary to withstand any considerable pressure.

In order that he might secure enough material strength in the support of the semi-permeable membrane, not only to show the existence of osmotic pressure, but to attempt its measurement, Pfeffer, in 1876, formed this membrane in the walls of unglazed porous cups by placing these cups in a solution of copper sulphate and then filling them with a solution of potassium ferrocyanide. The two substances in solution enter the walls of the cup from opposite sides and form a precipitated semi-permeable membrane of copper

ferrocyanide. This appears as a fine brownish line in the walls of the cup, and when once formed prevents the further passage of either substance. It does, however, permit water

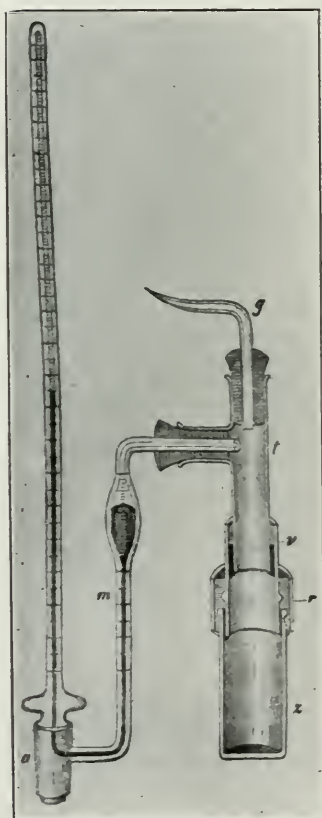


FIG. 1.

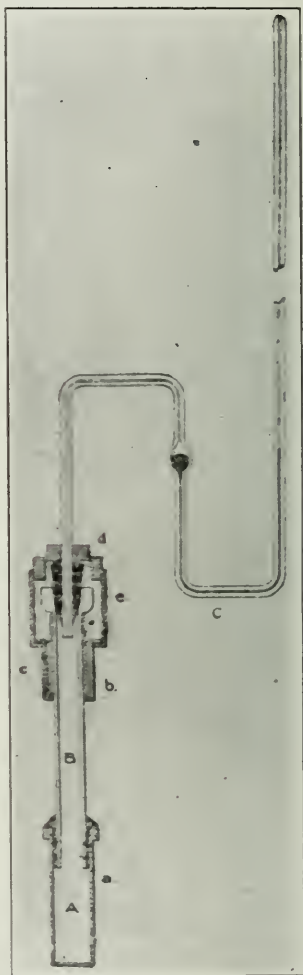


FIG. 2.

to pass through, and on this depends its value for the study of osmotic pressure.

The form of apparatus used by Pfeffer is shown in *Fig. 1*. In this *z* is the cup connected to the manometer by the glass

tubes t and v , and the collar r . The cup, which was of unglazed porcelain, was 46 millimeters high and 16 millimeters in diameter, while the manometer was 24 centimeters high. After being filled with the solution, the osmotic pressure of which was to be determined, the whole apparatus was submerged in a glass tank containing distilled water. The method of taking the temperatures and manometer reading is indicated in *Fig. 2*.

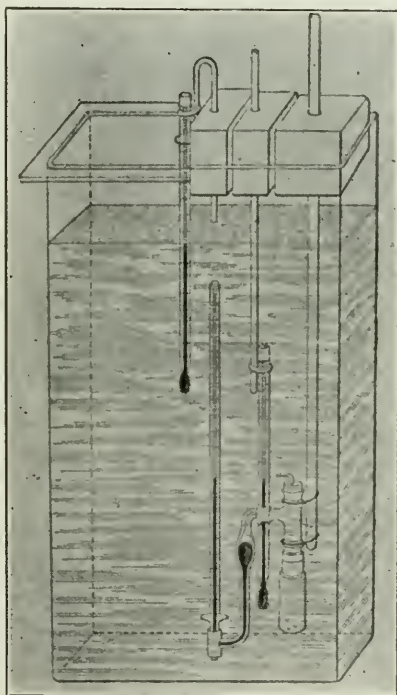


FIG. 2.

By far the most satisfactory work that has been done in the measurement of osmotic pressure has been carried on at the Johns Hopkins University by Prof. H. N. Morse and his associates.

What Professor Morse set himself to do was: to find some efficient way of getting rid of the air in the pores of the cups, since its presence is likely to make the semi-permeable

membrane discontinuous; to devise a quicker and more satisfactory way of forming the membrane in the walls of the cup; and to provide a form of apparatus that would withstand mechanically the enormous pressures developed.

The solution of the first and second of these problems has been satisfactorily accomplished, and very substantial progress has been made toward the solution of the third. In order to free the walls of the cup from air, advantage has been taken of the endosmose that results when a current of electricity is sent through a porous partition separating two electrolytes. On filling the cup nearly full with a boiled solution of potassium sulphate, immersing this cup in a beaker of the same solution and sending the current from the electrode surrounding the cup to the one within it, the current is accompanied by the passage of a considerable quantity of water through the wall into the cup, and this movement of the water sweeps the wall free of air.

This process requires about an hour, and 300 cubic centimeters of the contents of the cup frequently need to be removed in order to keep it from overflowing. To form the semi-permeable membrane the cup is placed in a beaker and surrounded by a cylindrical electrode of sheet copper. A platinum rod is placed in position inside the cup for the other electrode. Connection is made with a dynamo giving as high as 110 volts with the positive pole connected to the copper electrode. A tenth normal solution of copper sulphate is poured into the beaker while a tenth normal solution of potassium ferrocyanide is poured simultaneously into the cup. Endosmose takes place rapidly at first, but gradually decreases as the membrane is formed, while the electrical resistance increases until it reaches 2,000 ohms in ordinary porous cups, and as high as 200,000 ohms in hard burned cups.

In using this form of cup for the measurement of osmotic pressure it was found that the main difficulties to be overcome were of a mechanical nature. In order to secure the requisite strength of the connections certain devices were employed which are shown in *Fig. 3*.

A is the cup containing the semi-permeable membrane.

At the upper end there is placed between the inner wall of the cup and the porcelain tube *B*, a hard rubber or soapstone ring. This is turned to fit a groove cut in the inner wall of the cup with a carborundum wheel, and is cemented into place with a cement of litharge and glycerine. The upper surface of this cement is rendered impervious to the solvent in which the cup is immersed, by a coating of a solution of rubber and paraffin in carbon bisulphide.

The porcelain tube is ground to fit the inside of the ring with great exactness, and the ring is fixed upon it with shellac before it is fastened into the cup. To fasten the tube and ring into the cup a quantity of shellac is placed in the space above the ring at the top of the cup and the temperature is raised until the shellac melts. The cup and tube are then placed in a hot-air bath and baked until the shellac and rubber cement are hard.

The upper end of the porcelain tube is ground on the inside to receive a rubber stopper, through which passes the lower end of the manometer tube *C*. In order to keep the pressure from forcing this tube out of the stopper it is pushed through to a distance of about 3 centimeters and is then heated to a temperature above the melting point of shellac. By applying the gum a ring is melted around the tube, which, after cooling, effectually prevents its passing out of the stopper.

The stopper is kept in place by a brass screw-cap, *d*, that is threaded to fit the collar, *e*, which is kept in place by a flange fitting over a companion flange on the collar, *b*.

This collar is itself threaded to fit a tube, *a*, that is cemented to the porcelain tube under the enlarged upper end.

Professor Morse reports the experiment that gave the maximum pressure as follows: Resistance of the membrane not exactly known, but over 200,000 ohms. Solution of sugar N / 100 with respect to potassium ferrocyanide, and the water in which the cell was immersed N / 100 with respect to copper sulphate. The solution of sugar fresh and free from invert sugar. Cell set up at 5 P.M. Pressure at 5.10 P.M., 7.89 atmospheres; at 6.45 P.M., 31.41 atmospheres

(corrected). Temperature, 24.9° . Shortly after the second reading the glass tube was shattered.

From these results it is predicted that the osmotic pressure of a half-normal solution will be found to lie between 13 and 14 atmospheres at 20° , and probably between 13.4 and 13.8 atmospheres, while it is certain that for normal solutions of sugar it is not less than 31.4 atmospheres.

It will be observed that the experiment terminated by the breaking of the glass tube. It was the continued breaking of these tubes that led to the adoption of the porcelain tubes as described above. The necessity for great strength in every part of the apparatus is evident when we consider that the pressures obtained in this experiment are such as would be caused by a column of granite of uniform cross-section and a height of 423 feet.

SWARTHMORE COLLEGE,

December 17, 1903.

ERICSSON'S LOCOMOTIVE "NOVELTY" DISCOVERED.

An interesting railroad relic, reminiscent of the first days of the steam locomotive, has been discovered in the North of England. The Liverpool and Manchester Railroad Company, the first public road constructed, it will be remembered, inaugurated a competition in the latter part of the twenties of the past century for a locomotive, in which Stephenson and other inventors participated. Three engines—the "Rocket," by Stephenson; the "Sans Pareil," by Hackworth; and the "Novelty," by Braithwaite and Ericsson, respectively—participated in the trials that were carried out in 1830. As is well known, Stephenson's "Rocket" secured the award of \$2,500 which was offered, as being the most suitable engine, attaining a speed of 29 miles per hour. The "Sans Pareil" was second with a speed of 23 miles per hour, while the "Novelty" withdrew from the trials owing to the joints of the boiler giving way when the locomotive had traveled only 3 miles. Both the "Rocket" and the "Sans Pareil" are now preserved in the South Kensington Museum, but the "Novelty" mysteriously disappeared and was never found again until quite recently. It appears that Ericsson was so mortified by the failure of his conception, that he left it with his friend, Mr. Melling, who possessed engineering works located upon a space adjoining the Rainhill Station. These works were subsequently dismantled and the premises were occupied by the Rainhill Gas and Water Company. The "Novelty" was thus lost sight of, but it has now been recognized working as a stationary engine, the wheels having been removed for this purpose, and its identity thus somewhat disguised. Attempts are to be made to secure this third premier locomotive, and to place it alongside of its two contemporaries in the South Kensington Museum.—*Scientific American*.

Mining and Metallurgical Section.

Volcanic Origin of Oil.

BY EUGENE COSTE, E. M., Toronto, Ontario, Canada.

[Communication to the Secretary, in discussion of the paper of Robert T. Hill, Washington, D. C., on "The Beaumont Oil Fields, with Notes on other Oil Fields of the Texas Region,"* presented at a joint session of the Franklin Institute and of the American Institute of Mining Engineers, Philadelphia, May 15, 1902.]

In a recent paper† I took exception to the opening paragraph of the above paper of Mr. Hill, in which he says: "In endeavoring to interpret the geological occurrence of oil, the geologist is confronted by the fact that science has not yet solved the problem of its origin, which lies at the root of the subject. . . . For the present we must consider oil as a material in the rocks, the origin of which is still unexplained."

I take this second occasion to re-enter our objection to the above statement, as well as to the following similar statement of Messrs. Hayes and Kennedy in their recent bulletin‡ on these same oil fields: "The origin of petroleum is one of the most obscure problems by which geologists are confronted."

I claim that these statements, that we know so little to-day about the origin of petroleum, are not warranted in the present state of geological science, and I do not hesitate to state that, on the contrary, geology can to-day most clearly prove that the origin of oil is inorganic and the result of solfataric volcanic emanations.

* This *Journal*, cliv, 143, 225, 263.

† "Volcanic Origin of Natural Gas and Petroleum," *Jour. Can. Mining Inst.*, Vol. VI

‡ "Oil Fields of the Texas-Louisiana Gulf Coastal Plain." Bulletin No. 212, U. S. Geological Survey, Washington, D. C., 1903.

It has been so long assumed that oil or bitumen is due to the decomposition of the organic remains of the sedimentary rocks, that the words organic and bituminous are used synonymously, and accordingly, without attempt at explanation, the origin of oil is in every case ascribed to some bituminous shale horizon, more or less full of organic matter. Such fallacious reasoning attributing the origin of oil to bituminous shales or to shales containing oil—that is to say to oil—of course, proves nothing except that this question is prejudged and entirely misunderstood by a great many geologists who seem to regard the abundant geological proofs that oil did not originate according to the above axiom as extraordinary phenomena and profound mysteries not yet solved by science.

Chemistry can extract hydrocarbons from organic remains and can also produce hydrocarbons from simple mineral reactions (as in the commercial manufacture of acetylene, for instance), but the question before us is not: What are all the numerous chemical reactions capable of producing hydrocarbons or bitumens? but only: How does nature do it? What are the geological facts in this connection? If in chemistry hydrocarbons are generally grouped and classed among the organic compounds, it is not a proof that the natural hydrocarbons have geologically an organic origin and that, in geology, organic and bituminous are synonymous terms, to be exchanged and used indifferently, one for the other. The geological evidence is, on the contrary, very clear and very strong in disproving absolutely the organic origin of bitumens or hydrocarbons found in the earth's strata (excepting some marsh gas); and further, it shows plainly that the natural geological process of to-day and of ages past in the formation of these products is a mineral or inorganic process. This geological evidence is so well known and so indisputable that a simple enumeration of it seems to us sufficient:

(1) Animal organic remains or bodies are never entombed in the rock formations and, therefore, cannot there produce oil or anything else.

(2) Vegetable organic remains in the rock formations

always decompose into carbonaceous matter, that is, peat, lignite and coal, with a small production of marsh gas, which, however, either escapes in the atmosphere or remains in the coal, and has evidently nothing whatever to do with the natural gas and oil of the gas and oil fields.

(3) Further distillation of carbonaceous matter has not taken place in nature, except in very local and very rare instances, as proved by all the lignite and coal beds of the sedimentary strata.

(4) As reviewed elsewhere,* and as many very able geologists and scientists have repeatedly observed and recorded, in the volcanic districts of the earth, not only gaseous, liquid and solid hydrocarbons or bitumens are among the most important products of the solfataric volcanic emanations, but also carbonic acid, chlorides (mostly common salt), sulphuretted hydrogen, sulphur, gypsum and hot calcareous and siliceous waters are always the other conspicuous products of these emanations, and all these associated products together stamp the solfataric volcanic phenomena with a unique and unmistakable seal.

That this volcanic phenomenon is the normal and orderly process of petroleum production is to us also a most clearly established geological fact for the following reasons, which we have discussed at length in another paper: †

(a) It is the only geological process of petroleum production to be witnessed in active operation to-day in nature.

(b) In all the oil and gas fields or petroleum deposits the gaseous products are under a strong pressure which is not artesian or hydrostatic, which increases with depth and which cannot be anything else than a volcanic pressure.

(c) In some of the oil and gas fields heated waters, oils and gases are met with.

(d) All the oil and gas fields bear imprinted, largely through the products associated with the oil and gas, the seal we have referred to above as the distinct characteristic of solfataric volcanic emanations.

* "Volcanic Origin of Natural Gas and Petroleum," *Jour. Can. Mining Inst.*, Vol. VI.

† *Idem.*

(e) The oil and gas fields are located along the faulted and fissured zones of the crust of the earth parallel to the great orogenic and volcanic dislocations.

(f) Oil, gas and bitumens are never indigenous to the strata in which they are found; they are secondary products impregnating and cutting porous rocks of all ages, exactly as volcanic products alone could do.

(g) Oil and gas are stored products, in great abundance in certain localities, while neighboring localities often are entirely barren; and many of the strata among which they are found are so impervious that the source of these hydrocarbons must be the volcanic source below, which alone is abundant enough and alone possesses sufficient energy to force and accumulate such large quantities of these and associated products in so many spots through such impervious strata.

No other oil or gas fields conform to what has just been written more closely and more plainly than some of the fields under review in Mr. Hill's paper. Indeed, Mr. Hill shows that in the Texas Louisiana Coast Prairie:

(1) The oil and gas are always found under small mounds or salt islands, which are gentle recent quaquaversal uplifts or uplifted domes. This is fully confirmed by C. W. Hayes in a recent paper * and by others.

(2) The salt water and the oils under these mounds are still, in some cases, hot.

(3) The oil and gas under these mounds do not occur in any definite stratum, but in spots of many strata and in very large quantities in these limited areas.

(4) The same may be said of the products associated with the oil or gas under these mounds, viz., sulphur, sulphuretted hydrogen, salt, gypsum, limestones and dolomites, which form, under these mounds, many irregular masses and pockets without any stratigraphical order of any kind.

(5) The above associated products are not found in the wells drilled outside of the mounds any more than the oil or

* "Contributions to Economic Geology," Bulletin No. 213, U. S. Geol. Surv., pp. 345, 347, 348.

gas, except in very small quantity, while under the mounds they often form very thick vertical masses, hundreds and thousands of feet in thickness.*

If we keep these now well established facts carefully in mind we cannot come to any other conclusion but the one adopted by Mr. Hill, that "these materials (of the mounds associated with the oil and including the oil) have originated by secondary replacement, and that they may be of post tertiary age."

But, in his explanation of these secondary replacements under the mounds, Mr. Hill certainly does not go far enough. In my opinion, his explanatory hypothesis which he offers on page 35 as a "basis for discussion" and not "as a final explanation" should be altered as follows:

The oil, sulphur, salt, natural gas and hydrogen-sulphide pockets of the Texas Coastal Plain are not indigenous to the strata in which they are found, but are the resultant products of columns of hot saline, silicious, calcareous, magnesian and sulphur water and vapors, associated with sulphur and hydrocarbon gases and vapors, which have ascended, under volcanic pressure, at points along lines of structural weakness, and have disseminated also, in more or less minute quantities, a little oil, gas, sulphur and salt through thousands of feet of shales, sand and marine littoral sediments of the Coastal Plain section.

These lines of structural weakness or fissures were partially sealed by the deposition of the latter overlapping strata now capping the oil pools, but the spasmodic recurrences of the volcanic emanations kept raising and partially replacing the sands and clays of these latter strata to form in spots along these fissures the present mounds and salt islands.

It will be observed that Mr. Hill's "hydrostatic pressure" is here changed to a volcanic pressure, and that the other important change we suggest is that the saline waters as

* See also Capt. Lucas's paper, *Trans. Am. Inst. Min. Eng.*, Vol. XXIX, and the "Oil Fields of the Texas-Louisiana Gulf Coastal Plain," Bulletin No. 212, U. S. Geol. Surv., p. 126.

well as the hydrocarbon and sulphur gases and vapors are also of volcanic origin, instead of being derived from meteoric sources and from the strata and sediments beneath the Coast Prairie.

Before giving my reasons for the above suggestions, I wish to remark that they form a complete geological explanation of the origin of the oil and associated products of the mounds, while Mr. Hill's explanation is only partial and does not in any way solve the problem of the final origin of the oil, sulphur and salt which Mr. Hill simply admits, without explanation, to be disseminated in more or less minute quantities through the "bituminous" sediments of the Coastal Plain section. Nor does Mr. Hill's explanation account at all for the natural gas and for the sulphuretted-hydrogen gas which are two of the most important of the associated products of Mr. Hill's "oil-phenomena" of the mounds; it cannot, indeed, be admitted that the descending meteoric waters leach or gather also these gases downward through the sediments to the places of structural weakness or fissures, and then float these gases upward at a few spots along these fissures. My main reasons for the above suggested explanation of the origin of the oil phenomena of the mounds are based on the following simple facts:

(1) The oils, waters and gases under these mounds are not under an hydrostatic pressure, small or great. This is amply demonstrated by the fact that the once famous gushers of Spindle Top are already gushing no more and have now to be pumped. If the pressure there was artesian or hydrostatic they would be gushing yet, the same as at first, and, if the oil had exhausted in some of these wells, these would be gushing water out of the supposed artesian water column behind them. It is certainly now a well-known and admitted geological fact, that, in all the oil and gas fields, the rock pressure of the gas is a stored energy continually decreasing as the gas is used, so much so that the gas itself has to be pumped to-day in many fields where its pressure was too strong at first; and, surely, such a phenomenon cannot possibly have anything to do with an

artesian or hydrostatic water pressure. If not hydrostatic, then, what is it?

Messrs. Hayes and Kennedy, in their *recent report on these oil fields*, say: * "It appears highly probable that the pressure in the oil reservoir is due largely to the *expansive force of the associated gas*." Quite so! But this is hardly sufficient, and the question remains: What is the expansive force of the gas due to? It remains unanswered and cannot be answered unless we go to its real volcanic source. This one word "volcanic" explains it all! And the invocation of this word is here a forced conclusion. We have indeed seen that there is no sign of the "tremendous hydrostatic pressure" † of Mr. Hill in the wells of Spindle Top, which have to be pumped now; yet there is no doubt Mr. Hill is right in his conclusion that the oil and associated products have originated by secondary replacements caused by circulating waters (accompanied by vapors and gases), and if these waters and gases were not pushed by an hydrostatic pressure, that is, did not come from above, then they must surely have come from below, pushed by a volcanic pressure.

(2) In full support of this I must now call your attention particularly to what Mr. Hill calls ‡ "the association of oil, sulphur, sulphuretted hydrogen gas, gypsum, dolomite and salt, constituting collectively what might be termed the oil phenomena" of the mounds. Is not that association the unmistakable seal I have referred to above as belonging to the solfataric volcanic phenomena? And how could that unique stamp be found under these mounds unless they had been percolated by precisely the same hot waters, vapors and gases which are emitted in great abundance, and at times with disastrous violence and pressure, along the lines of structural weakness or fissures of the volcanic districts of the earth?

Therefore, along lines of faults or of structural weakness of the Texas-Louisiana Gulf Coastal Plain, volcanic gas-

* "Oil Fields of the Texas-Louisiana Gulf Coastal Plain," U. S. Geol. Survey, Bulletin No. 212, p. 135; also Bulletin No. 213, p. 350.

† In Mr. Hill's paper under discussion, p. 40.

‡ Mr. Hill's paper, p. 34.

aqueous emanations have issued in spots, like volcanoes do along volcanic ranges, constituting at each spot "an elevating force acting vertically and lifting a small portion of the earth's crust," as Mr. Hayes * puts it, but without explaining what the force was. This force, as Mr. Hayes also recognizes, "was active down to a very recent date;" in fact, it may be said to be active now, as in places the waters and oils are hot yet and the gases are still issuing. Thus the mounds and salt-islands of that region were formed exactly as sulfones, salses and mud volcanoes form to-day similar deposits in many typical volcanic districts of the earth, such, for instance, as in Italy† and in Java,‡ "where clouds of steam also issue from the vents and the heat is intense," and where sulphur, gypsum and salt are also abundantly associated. The only difference is one of intensity, which is less pronounced in the Texas-Louisiana region more remote from the centers of volcanic activity. An intermediate case between the mounds and salt islands of Texas-Louisiana and the Java mud volcanoes is the Trinidad Pitch Lake, which the able and most careful researches of Clifford Richardson || have determined to be unquestionably "the crater of an old mud volcano or geyser" with an influx of soft pitch at the center of the lake, amounting yet to thousands of tons yearly.

There is one more point in Mr. Hill's paper which I consider important to discuss in this connection of the origin of oil. Throughout the paper Mr. Hill divides the Texas oil deposits into two classes: the sheet-oil deposits and the pocket-oil deposits. In the first class he conceives the oil to be indigenous or nearly so, and to come from "bituminous" shales in close proximity to the sands. The bitumen (or oil) in the shales Mr. Hill admits and believes is due to the decomposition of organic matter.§ But even if that

* C. W. Hayes, Bulletin No. 213, U. S. Geol. Survey, p. 347.

† "Volcanic Origin of Natural Gas and Petroleum," *Jour. Can. Min. Inst.*, Vol. VI, p. 14.

‡ *Scientific American*, October 10, 1903.

|| "The Nature and Origin of Asphalt," Long Island City, N. Y., 1898.

§ Mr. Hill's paper under discussion.

were so (which of course we only admit now for the sake of argument), Mr. Hill does not explain how the oil was able to travel out of the impervious pores of the shales into the sands. No matter how close the proximity, we think that such a movement of the oil out of the shales would be impossible, as the characteristic condition of shales is to be absolutely impervious. Even under great pressure, as there is abundant evidence in the oil and gas fields, a few feet or even a few inches of shales prevent all leakages, so much so that shales are generally considered as forming, and often do form, the impervious covers or cap rocks of the sand reservoirs, and covers or cap rocks sealing tightly and hermetically the oil from below, cannot also logically be regarded as the source from which other sand reservoirs above have been filled.

In regard to the second-class or pocket-oil deposits, the foreign or adventitious nature of the oil and associated products is so glaring that for these Mr. Hill gives up the old idea of an indigenous oil made by decomposition of organic matter; but evidently this old idea is not going to be given up without a struggle, as it is retained for all the other deposits of Texas except for the ones of the Post-Eocene under the mounds, and even these are made to originate eventually from the same organic source, but in a less direct way through the intervention of circulating meteoric waters.

The only attempt Mr. Hill makes to prove this indigenous organic origin of the so-called sheet-oil is in these words: * "Of the 22,000 feet of sedimentaries in the Texas section, all but 2,000 feet are unconsolidated clays and sands, which *may be* more or less *bituminous*. . . . Some of the lime-stones *are* also *bituminous*. . . . Oil or bitumen *has been found* in at least a dozen horizons of the section In two instances in Texas *bituminous matter* (asphaltum) *is found* in apparently indigenous beds of lime-shell conglomerate. . . . The oil of the Corsicana field and that of San Antonio *is derived* from the shales of the Upper Cretaceous. . . . The strata on the Eocene Tertiary present every

* Mr. Hill's paper under discussion, p. 38.

favorable condition for the generation of petroleum, whether this material be derived from the decomposition of marine organisms, *as alleged by some*, or from the hydrocarbons generated by vegetable matter, *as believed by others*. *There are vast accumulations of both materials in Eastern Texas.*

. . . Between the Eocene or Claiborne stratum of Nacogdoches and the uppermost Pleistocene stratum of Beaumont, there are thousands of feet of gypsiferous clays and sands in which nature *may now be distilling oil*."

As will readily be seen, all the above proofs of Mr. Hill are simply assertions that bitumen or oil exists there (and, of course, that proves nothing as to its origin) or are suppositions against the known facts, viz., "that the oil is derived from the decomposition of marine organisms or of vegetable matter, of which there are vast accumulations in Eastern Texas, or is distilled from gypsiferous clays and sands." Is it not, indeed, known without the shadow of a doubt?

(1) That no bodies of marine organisms are or were ever entombed in these sedimentaries; shells or bones of millions of organisms were, but not one body. Just as it is in the sedimentaries being formed to-day along thousands of miles of coast lines, from which not one geologist has ever produced one entombed single body of marine or any other organism. So much for the "vast accumulations of marine organisms in Eastern Texas."

(2) Is it not also an undisputed recognized geological fact that the vegetable matter entombed in these sedimentaries (including the gypsiferous clays and sands) is to be found, and is found to-day as carbonaceous "undistilled" matter, containing yet the bitumens or oils which it would have produced had the temperature necessary for distillation ever been attained? Either there was distillation of these sediments or there was not, and the lignites, coals and other carbonaceous matter found abundantly in them to-day are most convincing proofs that there is not, and was not, sufficient heat there to cause distillation and to thus produce petroleum.

These simple geological considerations, then, lead us to

the safe conclusion that the so-called sheet-oil is not an indigenous product of decomposition of organic matter. That it is also, like the so-called pocket-oil, a secondary product of impregnation and replacement becomes quite clear when we remember that these so-called sheet-oil deposits are found not only in a dozen horizons, but in hundreds, from the oldest Paleozoic to the alluvial gravels and sands of to-day; and that nowhere do they spread like sheets; but that, on the contrary, they are always found in relatively very small pools in porous reservoir rocks, which are barren of oil outside of the little pools (exactly as in the case of the mounds), these pools forming only a very small percentage of the area of the numerous rock-sheets in which they are only occasionally found. That these accidental pools are only receptacles or reservoirs is admitted to-day by all who have studied the question. That these reservoirs were filled also from the great volcanic tank below, in a manner exactly similar to the case of the Texas mounds, is plain when all the evidence enumerated above, which geology can bring forward to-day, is considered together.

The above views on the origin of the oil phenomena, not only of the mounds and salt islands of the Texas-Louisiana district, but of all other oil deposits, lead one to a simple interpretation of the geological occurrence of oil which should be a guide to important results in the practical development of new oil and gas fields in the United States, as they have already been such a valuable guide to us in the developments of large new gas fields in Canada.* These views lead, indeed, to the following important conclusions:

Oil and gas were only supplied along some of the lines of structural weakness, or along some of the fractured zones of the crust of the earth, and therefore the new fields are to be found only along these zones or belts.

The numerous oil and gas fields known to-day indicate plainly quite a number of these oil belts, but more remain yet to be discovered, and new ones are coming rapidly to the front, especially in the United States. That this is the

* "Natural Gas in Ontario," *Jour. Can. Min. Inst.*, Vol. III.

solution of the problem of the geological occurrence of oil and of oil developments and explorations, the writer has long been convinced on the considerations and for the reasons given above. Our suggestions are therefore that, as far as practical results are concerned, the important point is to accurately trace these fissured zones or belts on good maps and to drill in the localities thus indicated.

I have been at work for years, ever since 1888, on maps of this character embracing North America, and I hope to be able to publish these before very long, and as soon as our present knowledge of these most important structural dislocations is a little more complete.

TORONTO, ONTARIO, CANADA,

December 5, 1903.

AN OPEN-HEARTH FURNACE MAKING STEEL BY A CONTINUOUS PROCESS.

In a recent number of *Stahl und Eisen*, Dr. Surzycki describes an open-hearth furnace that has been working satisfactorily since September, 1902, at the works of B. Hantke, at Czenstocha. In this furnace, which is of 30-ton capacity, two tap-holes situated one over the other, but not in line, lead into a double spout by which the whole or any part of the contents of the furnace are easily tapped at any time. The furnace is charged with cold scrap to which, when melted, molten pig iron from a blast furnace or a mixer is poured in. When the bath is quiet, iron ore and mill-scale are added, and a further amount of pig iron. The charging lasts until the furnace is quite filled. The charge is de-phosphorized by adding lime, and when de-carbonization has gone far enough the furnace is tapped. The de-oxidation of the steel is carried out by adding wood carbon and ferro-manganese in a ladle during the tapping of the charge. After tapping, the upper tap-hole of the furnace is closed and the furnace repaired. A calculated amount of ore and roll-scale and a proportionate amount of pig iron is then run in. The practice is carried out uninterruptedly for one to two weeks. If, from any cause, the remainder of the furnace contents must be cast, it is easily done by opening the lower tap-hole. The method, while based on the Talbot process, has the advantage that it may be worked in an ordinary fixed furnace, if not too small.

RAILWAYS OF THE WORLD IN 1902.

At the end of 1902 the railway mileage of the world was 352,500 miles, of which the United States had 202,471 miles, or 38 per cent., and Europe had 180,708 miles, or 34 per cent. The British Empire had 91,485 miles, or 17 per cent. of the total; the German Empire had 32,753 miles, and the Russian Empire, 31,945 miles. The United States had, therefore, six times as much mileage as either the Russian Empire or the German Empire.

CHEMICAL SECTION.

Stated Meeting, held Thursday, March 17, 1904.

Hydrogen Sulphide, Its Uses and Dangers.

BY E. GOLDSMITH,
Member of the Institute.

It always seemed to me a far-fetched idea that "Pythia," the oracle of Delphi, who, while in the state of ecstatic frenzy, uttered words and shrieks which were assumed to be the answers of the invisible Apollo, was thrown into this state by inhaling a peculiar vapor ascending from the earth, within the *aditon* (*ἀδῖτον*). It interests us here simply for the reason that the purely fanciful assumption has been made that the vapors that issued from the *aditon* were those of hydrogen sulphide.

That this gas is one of those bodies which excites the senses strongly no one can contradict or will dispute. The ancient authors, however, did not give us a clear and sufficient description of the gaseous matter which their oracle inhaled; because our science, "Chemistry," had not dawned upon the ancient people of Greece. That this strongly odoriferous gas was not described by the ancient authors is somewhat surprising, inasmuch as it is so frequently met with issuing from springs and craters on the northern shore of the Mediterranean Sea.

In the United States many so-called sulphur springs, as they are usually termed, occur, as, for instance, at Niagara Falls, the Yellowstone National Park, Wyoming, the Stink-water River; and many other localities are known, where hydrogen sulphide is exhaled to the disgust of those who live in the neighborhood.

Now, in spite of the fact that the preparation called "milk of sulphur" was known in commerce at a very early date in the Middle Ages, the peculiar and malodorous gas, H_2S , which is regularly evolved in the process of precipitating sulphur from a polysulphuret by an acid, was not recognized prior to the eighteenth century.

The first investigators were von Meyer and Rouell ; later on, Scheele and Berthollet determined the properties and the composition of hydrogen sulphide.

It is not surprising that chemists endeavored to explain the occurrence in nature of this singular compound mineral ; and a number of hypotheses have been suggested. The one, that organic matter reacts on sulphates seems to be generally adopted, since this reaction has been observed in rivers and at the mouths of rivers, as, for instance, on the west coast of Africa, where the waters of the Congo and other streams laden with organic matter, when they mingle, are said to mix with the sulphates in the ocean, are said to exhale hydrogen sulphide, the reduction being stimulated by the heat of the sun.

That hydrogen sulphide is liberated by the decomposition of organic matter is universally known ; that meats, eggs, fish, and certain vegetable matters which find their way into the sewers of cities play their part in contaminating the air we breathe, has been so often discussed, that I think it is not necessary to dwell upon it here ; I only wish to call attention to the fact that the hypothesis above referred to seems to be plausible.

Quite remarkable is the presence of hydrogen sulphide in the boric-acid fumaroles in Tuscany, where Saint Claire-Deville and Lebbancs (*Comp. Rend.*, t. xlvii, p. 317) found this gas in quantities from 1.62 per cent. to 4.1 per cent., an amount which must be considered extraordinarily high.

Coming now to the artificial production of hydrogen sulphide, it is noteworthy that hydrogen and sulphur do not directly combine with each other, even if sulphur be heated in an atmosphere of hydrogen ; but, according to Scheele and Humphry Davy, if hydrogen be allowed to pass through melted sulphur for a considerable time some hydrogen sulphide is formed. It is well known to chemists that the gas under consideration is readily formed by the interaction of many metallic sulphides and diluted mineral acids ; in the nascent state, both elements—hydrogen and sulphur—easily “interpenetrate” to form the compound gas.

To describe the various forms of apparatus devised for

the production of hydrogen sulphide on the small or large scale will be unnecessary, as descriptions and illustrations of them may be found in almost all text-books on applied chemistry. One point may be of interest to state, since it is not generally known, namely, that the hydrogen sulphide is sometimes stored in large gas-holders—like the great structures erected for illuminating gas—over salt water, of course—for technical purposes on the large scale.

In all cases, however, the gas produced requires to be washed before it is brought in contact with any other substances, to avoid contamination with impurities—a matter of importance in analytical work.

The usual material from which the gas is obtained is sulphuret of iron; but sulphuret of manganese or the trisulphuret of antimony, or, better still, sulphuret of calcium or barium, may be substituted for the iron salt, etc.

Calcium or barium sulphides furnish hydrogen sulphide of a high degree of purity; and it is to be recommended that calcium or barium sulphides be used, wherever the purest kind of H_2S becomes a necessity, as, for instance, in forensic investigations of poisoning cases.

Professor Reintsch observed that, if suet and sulphur are melted together in a retort, a pure hydrogen sulphide is obtained.

Hydrogen sulphide, at ordinary temperatures, is a colorless gas, having an extremely unpleasant odor, similar to that of rotten eggs. Its specific gravity is 1.1912 (air = 1). The gas is soluble in water to the extent of from two to three volumes in one volume of water at ordinary temperatures; but in alcohol, hydrogen sulphide is held in solution to even more than four times its own volume at the same temperature. However, the alcoholic solution of the gas, in the course of time, after several months, deposits crystals of pure sulphur, indicating that a slow decomposition of the compound gas has taken place.

In the dry state the gas may be condensed to a liquid, although it requires considerable pressure and a low temperature to effect such condensation.

Near $-85.5^{\circ}C.$, liquefied hydrogen sulphide becomes crys-

talline and appears like snow, or a transparent solid mass. It was Faraday who first succeeded in astonishing the scientific world by performing this remarkable experiment.

Liquid hydrogen sulphide possesses a strong refractive power; it is lighter than water; dissolves sulphur when heated and lets it fall again upon cooling. These facts were ascertained by Nieman.

The gas, or its watery solution, is of great importance in analytical chemistry. The fact that hydrogen sulphide possesses the property of combining with sulpho-bases to form the so-called double salts, indicating thereby its acid tendency, which is also recognized by its action on certain vegetable colors, leaves no doubt, according to the dualistic hypothesis, that hydrogen sulphide is an acid.

If hydrogen sulphide is passed through a red-hot porcelain tube, it is decomposed into its constituents—sulphur and hydrogen. The same decomposition occurs when the gas is subjected to the action of the galvanic current; sulphur travels to the anode and hydrogen to the kathode. Oxygen, or substances which easily part with their oxygen, act in a similar manner; they oxidize the hydrogen to water and liberate the sulphur; or, if the supply of the oxygen is great, the sulphur may be oxidized into sulphuric acid. The turbidity, often observed in the watery solution of H_2S , is simply the manifestation of such a decomposition into hydrogen and sulphur caused by the oxygen of the air.

Iodic, bromic, chromic, chloric, etc., acids are readily reduced by hydrogen sulphide. If hypochloric acid or fuming nitric acid be brought in contact with hydrogen sulphide, the oxidation is so intense as to cause inflammation, and even explosions may be induced. The free elements, chlorine, bromine and iodine, also react energetically upon hydrogen sulphide to form their respective hydrogen combinations, and liberate the sulphur. This property is made use of sometimes in practice on a large scale to form hydroiodic as well as hydrobromic acid, especially when these acids are demanded in a highly concentrated state.

The atmosphere of dwelling-houses, which from some cause or other become impregnated with hydrogen sul-

phide, and which, therefore, may become detrimental to health, may be purified by either evolving chlorine, or, more simply, by placing vessels containing chloride of lime in the various rooms.

Sulphurous acid and hydrogen sulphide unite to form a body which has received the name of pentathionic acid.

The importance of hydrogen sulphide in analytical chemistry, already referred to, is so great that all attempts to displace it by another reagent have thus far failed. No one in the past was more impressed with the usefulness of this gas for chemico-analytic work than the eminent German chemist, Justus von Liebig. It was he who raised hydrogen sulphide to the dignity of a group-reagent; and so successful was he with the system he suggested that all the schools in which chemistry is taught, in Europe as well as in America, have adopted it.

As a group reagent it plays its great roll in all laboratories of the world, and wherever chemical investigations are carried on it is well-nigh indispensable.

It will not be necessary to point out the groupings of the various chemical elements which Justus von Liebig first taught us to recognize in a highly complicated mixture. The general scheme can be found in the numerous textbooks published since Liebig's time, and is familiar to every tyro in the science of chemistry.

We must not omit to state that hydrogen sulphide is also employed in certain metallurgical processes on a large scale. For instance, to produce pure cadmium, for which there is a constant demand in the market, copper-nickel residues by the thousands of gallons in solution are treated with the gas in question; and it seems to be at the present time the only method by which a complete separation of the two elements can effectually be accomplished.

The odor of hydrogen sulphide is so penetrating that even the merest trace can be recognized with a fair sense of smell. Traces of the gas may be made visible by its well-known reaction on paper saturated with acetate of lead, which will darken quickly if held within an atmosphere containing this interesting invisible sulphur compound.

Other compounds, like the silver and the copper salts, may also be used for the same purpose as the lead salt.

Hydrogen sulphide is very poisonous even to plant life. A green finch died immediately in an atmosphere containing only $\frac{1}{1500}$ of its volume of H_2S ; $\frac{1}{800}$ part in air killed a medium-sized dog; $\frac{1}{200}$ part of H_2S in air suffocated and killed a horse. These toxic properties on animal life are, I think, sufficient to show the strong effect it has in what we may call comparatively small quantities. That plants are also strongly affected by the presence of the hydrogen sulphide in the air, and die, has also been observed.

To those who are employed in chemical works hydrogen sulphide occasionally plays the part of a subtle and dangerous foe. Many years ago in the factory where carbon disulphide was manufactured on a large scale, the workmen, as well as those who had to use the product, were subject to a variety of physical disorders. It was believed at first that the carbon disulphide caused the troubles. The principal symptoms were general weakness, loss of appetite, and especially a serious affection of the eyes, which exhibited itself, when the subject had been long enough exposed, in a blurring of vision and temporary blindness.

About twenty-five years ago, I was consulted with the view of ascertaining the cause of these troubles and of the nastiness, as it was called, of carbon disulphide and of finding, if possible, a means of removing it. In the analytical treatment of the sample of carbon disulphide, I found that it was a mixture of two sulphur compounds—carbon disulphide and hydrogen sulphide. After separating the latter gas from the liquid and thorough washing with water, the carbon disulphide lost its nasty odor; in fact, the odor of the fluid compound now was rather a pleasant, ethereal one. The cause of the odor of rotten eggs being removed, the true odor of the carbon disulphide appeared. Since that time complaints against this substance have ceased; that is to say, if the toxic and obnoxious hydrogen sulphide gas is removed from the carbon disulphide the health of the users of the article is no longer affected.

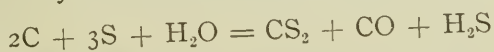
The manufacture of carbon disulphide is now controlled

by a single maker, and he should be compelled by law not to distribute a product contaminated with hydrogen sulphide. He was taught the process of purification through my efforts, and being, therefore, familiar with it, should conscientiously practice it to avoid the poisoning of the artisans who have to handle it.

Now, another question arose, How does the hydrogen sulphide get into the carbon disulphide? Since the hydrogen sulphide causes a loss of sulphur, it is self-evident that its formation should be prevented.

I found the cause in the fact that the sulphur is exposed to the influences of the weather. The raw sulphur is usually kept in the open air and rain, snow; dust, which also carries moisture, mingles with it.

The moisture in those days was not removed from the sulphur prior to feeding it into the cylindrical apparatus in which the combination is effected with the red-hot carbon. The moisture is, therefore, the cause of the formation of hydrogen sulphide. It is a well-known fact that the vapor of water is decomposed at a red heat to form hydrogen and carbon monoxide. The hydrogen being liberated and in the nascent state, meets the sulphur and by interpenetration forms the gas hydrogen sulphide. The reaction may be illustrated by the following equation:



It is, therefore, of importance that the sulphur should be dried before it enters the red-hot cylinder or the electric furnace wherein the formation of the two solids takes place to form carbon disulphide.

All the carbon disulphide placed on the market should be purified from hydrogen sulphide, and no other should be allowed to reach the consumer.

But how shall the workmen be protected in works where large volumes of hydrogen sulphide are evolved either as a reagent or as a secondary product? The answer is: that the operation must be conducted in a chamber connected with a high chimney. The workmen, however, disregard frequently the order given them not to put their heads

within the gas-chamber, and the consequence is that they become temporarily blind for two or three days, or longer, suffering intense pain, with reddening of the conjunctiva; almost continual running of tears, headache, and general indisposition. Under my direct observation came three men who were affected in the manner described, and there is not the slightest doubt that the hydrogen sulphide was the cause of the trouble.

When I observed the pupils of the affected eyes they appeared gray, more or less opaque; indicating, apparently, that the hydrogen sulphide must have formed with the outer cuticle a compound which prevented the light from passing into the eyes. The patients could not distinguish objects held before them; they could not find their way home alone, and, as may be imagined, feared to lose their eyesight entirely; which, however, always returned to them, and to all of them, after the lapse of several days.

This, in my estimation, extraordinary fact, which belongs rather to physiological chemistry, has been observed by the writer repeatedly on a number of workmen.

They, as a rule, went to the hospital for treatment. The diagnosis must have been a puzzle to the physician in charge, inasmuch as the workman could never explain the cause of the trouble. Therefore, this short story told of hydrogen sulphide may be considered as a small contribution to physiological chemistry for the benefit of those especially who have to diagnose and treat affections of the eyes.

Many working people at present are exposed to dangers from noxious gases in the various industries, and it seems to me, in this connection, that the effects of these gases, especially upon the eyes of men and domestic animals, are not sufficiently considered and emphasized. Whenever observations like the above are made the facts should be published in the interests of humanity.

PHILADELPHIA, March 17, 1904.

Notes and Comments.

ARTIFICIAL RUBIES.

In 1887, M. Frémy, with the aid of his *preparateur*, M. Verneuil, undertook new experiments on the crystallization of alumina, and had the satisfaction of obtaining very beautiful artificial rubies. The method employed consisted in causing the reaction at a red heat of barium fluoride on alumina containing traces of potassium bichromate. The new crystals, instead of being formed in a hard, vitreous, lamellar gangue, like that obtained in 1877, now appeared in a porous and friable gangue, regularly crystallized and of absolute purity. The samples presented to the Academy of Sciences were recognized, after examination, as formed of pure alumina, only colored with traces of chrome, and in all points to be compared with natural rubies. Their crystallization is rhomboidal, their brilliancy really adamantine, their shade exact and their transparency perfect. They have the hardness of the natural ruby; and, like it, become black when heated, resuming their beautiful rose tint on cooling.

Now M. Verneuil, to-day professor at the Museum, has discovered the method of producing the ruby artificially by melting a mixture of alumina and oxide of chrome at a constant temperature of several thousands of degrees, and in layers superposed from the outside to the inside, in order to prevent the production of cracks in the crystalline mass. This eminent chemist has succeeded in creating a magnificent ruby, weighing about 2,500 grams, and having a commercial value of about 3,000 francs.

For securing the extreme temperature indispensable for the success of this operation, M. Verneuil had recourse to a vertical oxyhydrogen blowpipe, the flame of which was directed from above downward. The hardness of the stone was secured by an energetic tempering, suddenly suspending the action of the blowpipe.

The ruby of M. Verneuil has admirable fluorescence, on account of its great purity. It possesses all the physical properties of the natural ruby, and, like the natural ruby, can be cut and receive a very beautiful polish.

We hope that now the desire expressed by MM. Frémy and Fiel in 1877 will be realized, that industry will draw advantage from this splendid discovery, and that the jewelers and the general public will share the advantages. A manufactured ruby is not to be considered as a spurious ruby when it possesses all the crystallographic, physical and chemical properties of the natural ruby. We see no reason why any difference between them should be established. Further, and from the very fact that such a stone is the marvelous result of the incessant efforts of experimental science, it should have for us as much value, if not more, than the natural ruby.

SHIP CANAL TO CONNECT THE BALTIC AND BLACK SEAS.

It is stated that an American syndicate has proposed to the Russian government to construct a canal from the Baltic to the Black Sea for the sum of

\$160,000,000, which is one-third less than the estimated official cost. The junction of its great northern and southern seas by a navigable estuary of sufficient width and depth to permit of the passage of men-of-war and ships of great tonnage has long been a favorite project in the councils of the Czar. At the present stage of the undertaking there are two, and only two, plans of procedure. One is to utilize the existing Beresina Canal by widening, deepening and generally extending it; and the other, to adopt a perfectly new route altogether. According to the *Uhland Verkehrszeitung*, the plans of the canal have been recently deposited with the Minister of Ways and Communications, in which the proposed new route has been minutely and fully defined. The canal will commence at Riga, which, next to St. Petersburg, is the most important of the Baltic ports of Russia. It will avail itself, wherever practicable, of such portions of rivers, canals and other waterways it may meet with in its course as can be made to profitably contribute to the success of the whole undertaking. For 125 miles it will absorb a part of the channel of the Divinea, as far as the fortified town of Dunaburg. Thence it will run through a deep straight cutting 100 miles long, and join up with the river Beresina at Lepel. From this point it will follow the canalized river to its junction with the Dneiper, and use the latter stream for the rest of its course to the Black Sea at Kherson, to the west of the Crimea, near Odessa. From the one sea to the other the distance will not be less than 1,000 miles by the new scheme of inland navigation. The cost of construction, according to the offer made, would amount to \$160,000 per mile, which is not an unreasonable price to pay. In addition to the value of the canal as a considerably cheaper route for the transport of goods, it would in war times possess a strategic importance probably exceeding that belonging to the "Kaiser Wilhelm" waterway. It is calculated that Russian armorclads could thus navigate the kingdom from sea to sea in half a dozen days.—*Scientific American*.

Book Notices.

The Metric Fallacy, by Frederick A. Halsey, and *The Metric Failure in the Textile Industry*, by Samuel S. Dale. New York: Van Nostrand & Co. 1904.

This book is an outgrowth of a paper presented to the American Society of Mechanical Engineers, December, 1902. The first named author is associate editor of the *American Machinist* since 1895, though the style of both parts of the book would seem inconsistent with even limited editorial experience, or the possession of the most modest ability for dispassionate discussion, the writer of the preface hurls himself against the two hundred million people more or less who have been heretofore contentedly conducting their affairs by the metric system, and ignorant of the losses they were thereby incurring, and the ludicrous position they were occupying in the opinion of the authors of this book. At the outset we learn that the whole world had failed to comprehend the "limited use of the metric system," because no proof to the contrary had been offered, until Messrs. Halsey and Dale produced it. The advocates of the metric system have, with malicious duplicity, conveniently

assumed, "when any Government passed a law favorable to the system," that the law was enforced. These editors are sorry for the millions turned into ridicule by this 231 page octavo, but the sufferers have only themselves to blame. Do these ill-informed metricians imagine there has been an extensive literature on the subject? On the contrary, this book is "the only considerable collection of facts relating to the use of the system that has ever been published." Think of that! Since its adoption after all European countries had been invited to a conference to secure uniformity of weights and measures, which France, the Netherlands, Denmark, Sweden, Spain, Switzerland, Sardinia, Rome, and the Cis-Alpine and Ligurian Republics actually attended; after Borda, Lagrange, Laplace, Monge, Condorcet, had exhaustively considered the respective advantages of Huyghens' pendulum and Picard's arc of the earth's circumference, and decided in favor of the latter; after Thomas Jefferson, John Quincy Adams, Bache, Hilgard, and a host of Committees of Societies, Parliaments and Congresses have turned the question inside out for one hundred years, it has remained for Messrs. Halsey and Dale to give to the world "the only considerable collection of facts"! The first sentence of the introduction is an illustration of the kind of facts these gentlemen are capable of giving. "The English system of weights and measures *is the exclusive standard of all English-speaking countries*, the metric system is the exclusive standard of no nation on earth." (Italics ours.) The sufficient reply to this is that in Great Britain and her Colonies the metric system has been legalized since 1864, and in the United States since 1866, consequently it is the grossest of errors to assert that the English system is the exclusive standard. If it be answered that the English standards are used in fact, though others may be recognized as legal, the rejoinder is that long before 1860 a large number of the workers of both Great Britain and the United States, namely, those in science, used and have ever since used the metric system exclusively. Moreover, a very large and increasing number of pharmacists, tailors, cabinet and instrument makers and others have used the metric system from early in the last century to the present time. In view of these facts what excuse can the authors of this book offer for the reckless statement above quoted? This is a specimen of the book's accuracy.

As an example of its fairness we see on page 13 a sub-heading "Pro-metric Argument." On reading the two and a quarter pages which profess to give this argument we find only quoted opinions of various persons that the changes could be effected in a short time (most frequently two years). All the powerful array of calculations and statistics of a century are ignored. On the following page and a quarter, entitled "The Anti-metric Argument," one finds difficulty, persistence of old units; destruction of mechanical standards; uselessness for foreign trade; the bill before Congress is a compulsory measure (most governmental laws are); the metric system has no superiority, and no time is saved by employing it; the confusion in the English weights and measures is a fiction; that our units are the best in the world.

It is useless to pursue seriously the unreasoning denunciations of a book published in this spirit. The negative of the question is insisted upon with an absence of supporting facts and with a vehemence characteristic of a school debating club. A great deal of space is devoted to proving that non-metric

units are used in countries where the metric is the established system. To a limited degree this is true. Diamonds are sold both by the carat and by the grain; the circle is divided into 360° both in France and Germany; but the inference which is drawn from the parade of names of measures not metric on pages 60 to 69, is amusing to those who are familiar with the customs in some of the countries mentioned. It looks as if the author of this list had collected together all the archaic names for measures of quantity which have ever been used, and made of them an alphabetical arrangement, putting opposite to each name of a measure the country where it once was used. Probably not five per cent. of the measures given are now used as intimated; but if, instead of this, all were used, they would not together make as large a percentage of foreign matter in the infinitely expansible metric system as the words of foreign origin in the text of the book before us; yet its authors would not admit that their English was a failure. The attempt in the second part to show that the metric system is not adapted to the textile industries is thrown away. The metric system binding together line, area, capacity, and weight, provides new units at any of the multiples or subdivisions of its scale, which latter are spread out evenly from the smallest to the greatest, instead of being crowded together at uneven intervals, as are the English units. By the simplest of laws all these divisions are commensurable without other than definite decimal fractions. If need be, the scale or net or cube may be based on a unit which is the thousandth, or the millionth for that matter, of the millimeter if an atom or a light wave is to be measured. This same scale will furnish units for expressing the distances of the stars by mere multiplication by the powers of ten. To pretend that such a system is incapable of meeting the wants of yarn manufacturers is absurd.

The authors have a perfect right to object to a change of their standards and to familiarizing themselves with a system to which they have not been accustomed. This is only natural and human, and, in fact, is a necessary consequence of any attempt at improvement or reform; but if they have not the time or the inclination to possess themselves of the literature and the facts connected with the movement; and if they are unable to discuss the question calmly with scientific accuracy they should not publish a book on the subject.

F.

Franklin Institute.

[*Proceedings of the stated meeting held Wednesday, May 18, 1904.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, May 18, 1904.

PRESIDENT JOHN BIRKINBINE in the chair.

Present, 45 members.

Additions to membership since last report, 11.

The resignation of Dr. Henry Leffmann from the Committee on Science and the Arts is reported, and Dr. W. J. Williams is duly elected to fill the vacancy.

Mr. Horace Pettit, sometime Solicitor of the Institute, presented and commented upon the decision of President Judge Willson, of the Court of Common Pleas, No. 4, in the amicable suit instituted by the Institute against the Trustees of the Elliot Cresson Medal Fund to determine several questions of difference, but chiefly whether the Trustees are empowered under the deed of trust of Elliott Cresson, to exercise the right of passing judgment as to the propriety of the awards of the medal made by the Institute.

Mr. Pettit reported that the Honorable Court had decided the case in favor of the Institute on all points. The gist of the decision is that :

“So long as it (the Institute) acts in such a manner (*i. e.*, in good faith) we are of the opinion that the Institute must be regarded as having the right and the sole right to determine how and to whom the medals shall be awarded.”

Prof. Edgar Marburg then gave an informal account of the organization and methods and aims of the American Association for Testing Materials.

(Mr. H. R. Heyl in the chair.) Prof. A. E. Outerbridge followed with some remarks upon the “Dangers Arising from the Use of Cast Iron in the Construction of Steel Skeleton Structures.” The speaker, after alluding to his recent communication to the Mechanical and Engineering Section describing his observations on the permanent deformation (expansion) of cast iron by repeated heating and cooling (see the *Journal*, CLVII, 121; February, 1904), referred to the recent great fire in Baltimore, where numerous buildings in which cast iron had been used for door and window frames and other portions of interior construction, suffered practically complete destruction of their interiors from the distortion of this material; and that where cast iron had been used for the fronts of buildings, or their principal supports, they had suffered, in most cases, complete destruction. Emphasizing the radical difference in the behavior of steel (which is not permanently deformed on heating), the speaker called attention to the fact that in numerous cases, in Baltimore, where the interiors of steel skeleton buildings had been completely destroyed, the steel frame work had remained intact and in perfect alignment, having suffered no substantial injury.

Mr. W. N. Jennings exhibited and commented on a series of lantern photographs of views made during a recent professional trip in Cuba.

The thanks of the meeting were tendered to the speakers of the evening.
Adjourned.

WM. H. WAHL,

Secretary.

Committee on Science and the Arts.

(Abstract of the proceedings of the stated meeting, held Wednesday,
April 6, 1904.)

PROF. LEWIS M. HAUPT in the chair.

Present, 30 members.

The Secretary reported the election of Messrs. A. W. Allen, Richard L. Binder and Wm. H. Thorne as members of the Committee in place, respect-

ively, of Prof. Edgar Marburg and Clayton W. Pike, resigned, and Luther L. Cheney, deceased.

The following reports were acted on :

(No. 2246.) *Enclosed Arc Lamp*.—J. Allen Heany, Philadelphia.

ABSTRACT.—The invention is covered by United States letters-patent, No. 678,952, July 23, 1901, and No. 693,706, February 18, 1902, granted to applicant. The first of these relates especially to combined electro-magnet core and clutch for regulating the feed of the upper or movable carbon; the second has special reference to the application of a movable solenoid coil for readily changing the amperage of the lamp without changing the regulating resistance, and a dash-pot connected with the core clutch to prevent sudden movements or "chattering" of the upper carbon.

These features of construction require illustrations to be made comprehensible.

The report recognizes that the Heany lamp, in respect of mechanical construction, is exceedingly compact and light; also that it appears to be durable. The special features of construction covered by the patents above named are recognized as highly meritorious.

In tests of the lamp conducted under the supervision of the sub-committee, two of the Heany lamps (110 volts, 5 amperes) gave an average of 127 hours continuous burning with $\frac{7}{8}$ -inch carbons. A third lamp with $\frac{1}{2}$ -inch carbons ran for 162 hours—a performance which the sub-committee regards as "commercially" satisfactory. Furthermore, a lamp was short-circuited for one hour, with a current averaging 15 amperes, and, though the resistance wire and solenoid were heated cherry-red, and the adjacent parts were tarnished, the lamp suffered no permanent injury.

The award of the John Scott Legacy Premium and Medal is recommended to the inventor. (*Sub-Committee*: L. G. Rondinella, Chairman; T. Carpenter Smith, Charles C. Heyl, Kern Dodge.)

(No. 2279.) *Electric "Buzz" Fan*.—S. S. Wheeler, New York.

Referred to Sub-Committee for further consideration.

The following reports passed first reading:

(No. 2314.) *Metallic Fireproof Window*.—D. Lupton's Sons Company, Philadelphia.

(No. 2315.) *System for Storage of Coal, etc.*—James M. Dodge, Philadelphia.

(No. 2317.) *Parallax Stereogram*.—F. E. Ives, New York.

(No. 2319.) *Computing Machine*.—Charles W. Draper, Washington, D. C.
W.

WEDNESDAY, MAY 4TH, 8 P.M. Mr. Chas. E. Ronaldson in the chair. Present, 17 members.

The following reports were acted on:

(No. 2314.) *Metallic Fireproof Window*.—David Lupton's Sons Company, Philadelphia.

The subject of this report is a fire-resisting window constructed entirely of sheet metal and glazed with wired glass. The fire-resisting qualities of wired glass are now fully established and recognized by the underwriters, and this

material has made possible the construction of a window that will resist the passage of fire without being enclosed in metal shutters. The construction is such that it will close automatically under the influence of heat, a fire-safety provision on which much stress is laid by the manufacturers. Also, the sashes are so inserted in the sliding-sash styles that they may be caused to revolve, simplifying the task of window cleaning and doing away with the danger incident to performing this work from the outside. The mechanical details can be made intelligible only by illustrations.

The report of the committee finds that the following claims of the makers are substantiated, viz.: That the window is slightly and substantial; that it is an efficient fire-screen; that it is practically self-closing when subjected to unusual heat; that it is convenient in operation, easily managed for cleaning and unusually air-tight when closed. The manufacturers are awarded the Edward Longstreth Medal of Merit. *Sub-Committee*: H. R. Heyl, Chairman; Chas. A. Hexamer, Wm. McDevitt.)

(No. 2315.) *System of Storing Coal*.—James M. Dodge, Philadelphia.

This improved system and apparatus for storing and handling coal and analogous materials is protected by numerous letters-patent granted to applicant. The object sought to be accomplished is to handle large quantities of these materials, rapidly and with the minimum percentage of loss. The two chief functions embodied in the system are: (1) The stocking or trimming-out of coal to be stored, and (2) reloading the stored coal for shipment. In addition to these principal features there have been introduced arrangements for screening the coal before reloading into cars and for drilling cars by haulage. These operations are performed by continuous conveyors for the purpose of storing anthracite coal in heaps on level ground, on hillsides, or in buildings of any shape or capacity.

A number of extensive plants are operating under this system, handling many thousands of tons daily, and others are in course of erection. While official figures of the cost of storing and reloading are not accessible, the committee has had submitted to it evidence to prove that the labor cost will not exceed 3 cents per ton.

All the essential features of this system are fully covered by United States letters-patent, twenty-eight in number; of these the report enters into detailed description of eight, referring respectively to "Chain-Cable," "Chain Drive," "Chain-Wheel," "Removing Pile of Coal," "Process of Piling Coal," "Conveyor through Bottom," "Machinery for Handling Coal," and "Apparatus for Piling Coal." There patents range in date from No. 264,139, September 12, 1882, to No. 502,555, August 1, 1893. An intelligible description of all the details of the Dodge system and apparatus being impossible without the aid of illustrations, the reader is referred to the patent specifications and drawings. The following digest of the patents above named, will suffice for an understanding of its principal features, viz.:

The Dodge system comprises a chain conveyor supported by a sheer-truss, constituting a trimming machine, employed to pile coal, etc., together with a pivoted ground conveyor involving a flighted chain mounted upon a steel frame actuated by power in all its movements, and which is employed to reload the coal, etc., cars. The sheer-truss of each machine spans the pile to be formed and is fixed at the angle of repose of coal (27°).

One reloader is commonly employed with two trimming machines, forming a group; the storage plant will then consist of a number of these groups, and these may vary in capacity.

In operating a plant where the coal is received in a hopper beneath the receiving track, it is fed through a chute to the conveyor of one of the trimming machines, which carries it to the apex of the coal pile as it is building. The bottom of this conveyor is a steel ribbon 12 inches wide, which is wound from a drum located at the foot of the truss, so arranged that it is drawn out along grooves in the conveyor trough, and so that its end, or discharge point, is always at the constantly rising apex of the pile. As the arrangement only permits the coal to drop a few inches, the loss by breakage is reduced to a minimum.

The reloading machine consists of a horizontal and an inclined portion, which work together, in order to carry coal continuously from any horizontal position to a point where a pocket is located to receive the coal; thence it is discharged into cars or vessels. The horizontal portion of the reloader is pivoted at the foot of the incline and provided with wheels, which permit it to run on circular tracks, which latter are placed between and under the two heaps constituting a group. The power mechanism is so applied, that one man upon the platform operates the reloader, taking coal from either pile as may be required.

Each trimming and reloading machine handles 3 tons per minute, 180 per hour, or 1,800 tons per (ten-hour) day, so that while one pile is being stocked with one size, another size can be reloaded simultaneously from the other pile of the group. Its handling capacity equals 3,600 tons per day. A plant is therefore estimated by the number of groups it contains. Thus a plant of five groups (ten piles) can handle 18,000 tons per day; *i. e.*, 9,000 tons received and 9,000 reloaded. The speed of the conveyor is 100 feet for piling and reloading. The cost is 3 cents per ton handled.

Modern construction of anthracite coal storage plants under the Dodge system involves the use of conical piles varying in capacity from 25,000 to 60,000 tons per pile, having a diameter at the base of 247 to 331 feet. In order to form a pile having a capacity of 25,000 of anthracite coal, the trimmer trusses must be 153 feet long from center to center of pins; while for a 60,000-ton pile the trusses will be 196 feet long; 2,400,000 tons of coal are stored by means of this system in the United States, the largest plant having a capacity of 310,000 tons.

The report concludes as follows: "It appears that the successive inventions of Mr. Dodge have resulted in the development of an entirely new and economical system of handling coal, and one that varies widely from the system formerly in vogue. We are informed that during the interval of sixteen years since this system was inaugurated not one of Mr. Dodge's patents has been infringed, and this coal storage system has come to be regarded as a standard one."

In view, therefore, of its novelty and demonstrated utility the Committee recommends the award of the Elliott Cresson Medal to James M. Dodge for his improvements in the methods of storing and reloading coal. (*Sub-Committee*: James Christie, Chairman; Chas. E. Ronaldson, John M. Hartman.)

(No. 2317.) *Parallax Stereogram*.—Fred. E. Ives, New York.

The subject of this invention, covered by United States letters-patent, No.

725,567, April 14, 1903, granted to the applicant, comprises a photographic transparency which, without the use of a stereoscope or other optical device, shows the objects photographed in perfect stereoscopic relief; apparently as solid objects beyond, or in front of, the glass transparency.

The stereogram is composed of a photographic transparency, which is a line composite of the two images of an ordinary stereoscopic photograph, and an opaque line cover, mounted over the photograph with a separation of 1 millimeter.

The stereogram negative is made by placing a line screen in front of the sensitive plate and exposing the same in a camera having two lenses, or two openings in a diaphragm behind a large lens, placed about 70 millimeters, or the pupillary distance, from center to center. This initial negative is most readily made by means of two lenses which occupy the same focal length and relative position to the line screen and the sensitized plate that the eyes of the observer are to occupy in relation to the line screen and finished transparency.

The relative position of the image to the plane of the finished stereogram may be varied by the use of pivoted inverted prisms in connection with the lens or lenses at the time of taking the initial negative.

The positive from the composite negative is mounted with a line screen similar to the one used in making the exposure, and this combination, when viewed from approximately the same distance as the focal length of the lens, is resolved into a single picture in perfect stereoscopic relief.

This stereoscopic effect is caused by the fact that the elements of the composite picture alternate with each other, and, being covered by an alternately opaque screen, each eye picks up only one set of lines; namely, that set which represents those of the stereogram intended for it, while the lines constituting the other element are hidden from the eye by the opaque lines of the covering screen.

The report concludes that parallax stereograms may prove an interesting and valuable aid in demonstrating the principle of stereoscopic vision, in schools and colleges, and may also prove to be desirable and interesting as window transparencies.

In consideration of the ingenuity displayed by this device and the perfection of its operation, the award, to the inventor, of the John Scott Legacy Premium and Medal is recommended. (*Sub-Committee*: Martin I. Wilbert, Chairman; U. C. Wanner, J. W. Ridpath, Max Levy, Samuel Sartain, Chas. F. Himes.)

(No. 2319.) *Computing Machine*.—Chas. W. Draper, Washington, D. C.

This device is in principle a prepared table of the products of two series of a limited number of factors, so arranged that by operating the respective buttons the desired product will be the only one of the table of products that will be presented to view.

The details of the mechanism require for intelligible description the use of illustrations.

The report finds that the machine is a departure from other computing machines; also, that while it is limited in its individual application, it is capable of being adapted to a wide range of uses, not only for stores and market stands but also for various computations of limited range, such as

weekly pay rolls, etc. The Committee awards to the inventor the Edward Longstreth Medal of Merit for the ingenious conception and execution of this machine. (*Sub-Committee*: Hugo Bilgram, Chairman; E. Goldsmith, Geo. Hoadley, George S. Cullen.)

(No. 2324.) *Lincoln Lessons on Graphic Geography*.—McCaskey.

(An advisory report.)

The following reports passed first reading:

(No. 2320.) *Tent Fastening*.—James J. Rinn, Philadelphia.

(No. 2326.) *Feed Water Regulator*.— — Burrows.

(No. 2328.) *Storage Structure for Coal, etc.*—James M. Dodge, Philadelphia.

(No. 2186.) Protest of the Pelton Water Wheel Company, of San Francisco, against report awarding the John Scott Legacy Premium and Medal to Wm. A. Doble, same place, for Improvements in Tangential Water Wheels.

For reasons deemed sufficient, the sub-committee charged with this investigation reported that the allegations set forth in this protest are not sustained. The Committee's recommendation was thereupon confirmed, and the protest was dismissed.

The resignation of Dr. Henry Leffmann as a member of the Committee was presented and accepted.

W.

Sections.

[*Abstracts of Proceedings of Stated Meetings.*]

MINING AND METALLURGICAL SECTION.—*Stated Meeting*, held Thursday, April 21st, 8 o'clock, P.M. Mr. G. H. Clamer in the chair. Present, 96 members and visitors.

Major Ralph W. Abercrombie, U. S. A., read the paper of the evening on "The Copper River Country of Alaska."

The speaker described in his communication the work of two exploring expeditions conducted by himself, the principal object of which was to discover and locate a route from the seaboard to the interior of Alaska through American territory—a so-called all-American route.

The first of these expeditions, which was begun in 1884, engaged in the exploration and survey of the Copper River Valley to the Yukon drainage. The result of this expedition, "while it developed the topographical features of the Copper River Delta and Port Valdez, were of a negative character so far as developing an all-American route was involved."

The second expedition was undertaken in 1898, and had for its purpose a continuation of explorations from Prince William Sound to the Yukon River. The result achieved was the working out of the topography of almost the entire Copper River Valley, and the demonstration of the existence of an "all-American" route from Prince William Sound to the Yukon Valley.

The subject was freely discussed and the paper was referred for publication. The speaker received the thanks of the meeting.

Adjourned.

WM. H. WAHL,
Secretary.

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